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ECONOMETRIC AND TIME SERIES MODELS OF THE HOUSING SECTOR AND MORTGAGE MARKET

FINAL REPORT

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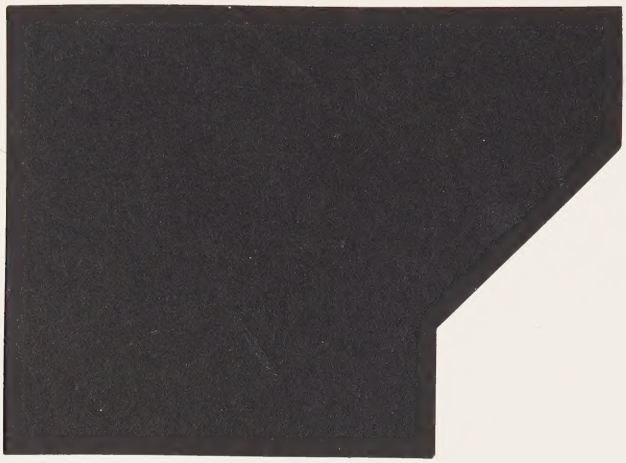

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Soo-Bin Park, Carleton University

H. James Brown, Harvard University

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Christopher Herbert, Harvard University

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for

Canada Housing and Mortgage Corporation

August 1992

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1. Aperçu

1.1. Introduction

La présente partie du rapport donne une vue d'ensemble du modèle économétrique structurel trimestriel du secteur de l'habitation et du marché hypothécaire canadiens. Ce modèle résulte des efforts de la Société canadienne d'hypothèques et de logement pour améliorer la qualité de ses prévisions dans les domaines de l'habitation et des créances hypothécaires.

Le modèle comprend deux volets : le secteur de l'habitation et le marché hypothécaire. Dans le secteur de l'habitation, les entreprises de construction utilisent capitaux et main-d'oeuvre pour produire des logements et ainsi générer des profits. Elles sont des fournisseurs de logements neufs. En devenant propriétaires ou locataires de logements, les ménages consomment les services de logement. Le secteur du logement est de plus étroitement lié au marché hypothécaire, car la somme d'argent nécessaire à l'acquisition d'un logement oblige les ménages à contracter une dette, le plus souvent un prêt hypothécaire.

Le modèle a été conçu suivant deux contraintes. D'une part, il doit être suffisamment petit pour que puissent s'appliquer les restrictions déterminées à partir de la théorie économique reçue en matière d'habitation et de crédit hypothécaire. D'autre part, le modèle doit donner lieu à des prévisions offrant un degré de désagrégation acceptable.

Un autre facteur contraignant, dans l'élaboration d'un modèle national de ce type, est le manque de séries chronologiques de qualité à propos des marchés visés. Le modèle final est donc forcément un compromis entre la théorie économique pertinente, les besoins relatifs à la désagrégation des variables, et l'accessibilité des données.

Les équations structurelles du modèle ont été estimées à partir de données trimestrielles fournies pour la période du 1er trimestre de 1963 au 4e trimestre de 1990. Les séries chronologiques de ces quelque 30 années, qui correspondent aux variables des marchés de l'habitation et des prêts hypothécaires, ne sont pas complètes. Par conséquent, la période formant l'échantillon du modèle varie d'une équation à l'autre, selon qu'il existe ou non des données se rapportant aux variables de telle ou telle équation.

La première partie du rapport est ainsi organisée : les renseignements détaillés sur les caractéristiques du modèle et sur les résultats de l'estimation sont présentés dans les chapitres 2, 3 et 4. Le chapitre 2 porte sur le volet habitation du modèle, tandis que le chapitre 3 a trait aux investissements résidentiels. La question du marché hypothécaire est traitée au chapitre 4. Au chapitre 5, une combinaison de prévisions est analysée. On trouvera de plus deux annexes à la fin du rapport; l'annexe A présente une liste des variables utilisées et des sources d'information pertinentes, et l'annexe B, une bibliographie sommaire.

1.2 Structure générale du modèle

La structure générale du modèle du secteur de l'habitation et du marché hypothécaire est exposée dans le diagramme de la figure 1.1. C'est du parc de logements (partie supérieure du diagramme) qu'originent les services de logement. Il s'agit de la somme des logements existants et des logements achevés, de laquelle on soustrait les logements exclus. Comme il existe une offre de services de logement, les prix évoluent en fonction de la demande, elle-même tributaire de facteurs tels que le prix des autres biens et services (mesuré par l'indice d'ensemble des prix à la consommation), le revenu permanent, les conditions démographiques ainsi que le coût et la disponibilité du crédit hypothécaire. L'équilibre du marché ne dépend pas nécessairement des prix, de sorte que des logements sont inoccupés à court terme.

Les mises en chantier sont fonction de la rentabilité prévue de la construction résidentielle, compte tenu du prix des logements et des terrains, du taux d'inoccupation et des coûts de construction. Les coûts de construction dépendent du niveau des salaires dans ce secteur, du coût du financement provisoire et de la situation courante de la construction résidentielle et non résidentielle par rapport à la capacité de l'industrie. Le prix des terrains résidentiels est en bonne partie déterminé par la demande, qui elle-même évolue en fonction des facteurs démographiques, du revenu permanent et du parc de logements existant. Bien entendu, le coût des emprunts hypothécaires et la disponibilité de prêts ordinaires ou LNH ont aussi une incidence sur les mises en chantier.

Le volet marché monétaire du modèle est représenté dans la partie inférieure du diagramme. La demande de crédit hypothécaire origine de la demande de

logements. Les mêmes facteurs influent donc sur la demande dans les deux cas, à l'exception des coûts de financement (c'est-à-dire les taux hypothécaires), qui touchent plus directement la demande de crédit. Comme on suppose que l'offre de crédit hypothécaire est pratiquement infinie, le nombre de prêts consentis par les institutions dépend donc en principe de la demande. Quand au taux hypothécaire comme tel, il varie selon le rendement offert par d'autres véhicules de placement (les obligations par exemple).

Pour simplifier la structure du modèle, aucune distinction n'est faite, dans la figure 1.1, entre les logements individuels et les logements collectifs. Cependant, la modélisation du marché de l'habitation tient compte de cette différence, les individus des deux sous-secteurs n'ayant pas un comportement identique. Les données relatives aux mises en chantier, aux achèvements et aux investissements dans la construction résidentielle sont en outre réparties selon le type de logement (maison individuelle, maison jumelée, maison en bande et appartement).

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PART ONE

STRUCTURAL MODELLING OF THE HOUSING SECTOR AND THE MORTGAGE MARKET

1. An Overview

1.1 Introduction

In this part of the report we present a description of the basic structure of a quarterly structural econometric model of the Canadian housing sector and mortgage market. The model is a result of the effort of the Canadian Mortgage and Housing Corporation to enhance its forecasting ability in the area of the housing sector and mortgage market in the Canadian economy.

The model is organized into two parts: the housing sector and the mortgage market. In the housing sector, construction firms employ capital and labour services to produce profit-maximizing output of housing units. They are suppliers of new dwellings. Households consume housing services by owning or renting homes. Further, the housing sector is closely interrelated to the mortgage market because the size of the outlay necessary for the households to acquire a housing unit requires debt financing via mortgages in most cases.

The design of the model has been constrained by two factors. The model must be small enough to allow the imposition of restrictions from received economic theory of the housing sector and mortgage market. On the other hand, the model must be disaggregated enough to forecast the housing and mortgage market activities at a fairly detailed level.

Another constraint on the construction of a national model of the housing sector and mortgage market comes from a lack of high-quality time series data pertaining to these markets. The final model is then necessarily a compromise based on the relevant economic theory, forecasting needs in variable disaggregation, and data availability.

Structural equations of the model have been estimated using available quarterly data in the period from 1963:1 to 1990:4. Time series data on many housing and mortgage market variables are not available for the entire 30 year period. Thus the sample period used in the model estimation varies from one equation to another, depending on the availability of data for the variables included in the equation.

The plan of Part One of the report is as follows. Details of the model specification and estimation results are presented in Chapters 2, 3 and 4. Chapter 2 is concerned with the housing sector of the model while Chapter 3 deals with residential investment. The mortgage market is the subject of Chapter 4. A combination of forecasts is explored in Chapter 5. The report has two appendices. Appendix A at the end of the report presents a

list of variables of the model and their data sources while Appendix B selected bibliography.

1.2 The General Structure of the Model

The general structure of the housing sector and mortgage market model is presented by the flow diagram in Figure 1.1. The housing stock at the top of the diagram provides housing services, and is the sum of the previous housing stock and housing completions less removals. Given the supply of housing services, housing price is determined by the demand for housing services which depends on the price of alternative goods and services (proxied by the all-items consumer price index, CPIALL), permanent income, demographic factors, and the cost and availability of mortgage credit. Housing price does not necessarily clear the market and vacancies exist in the short run.

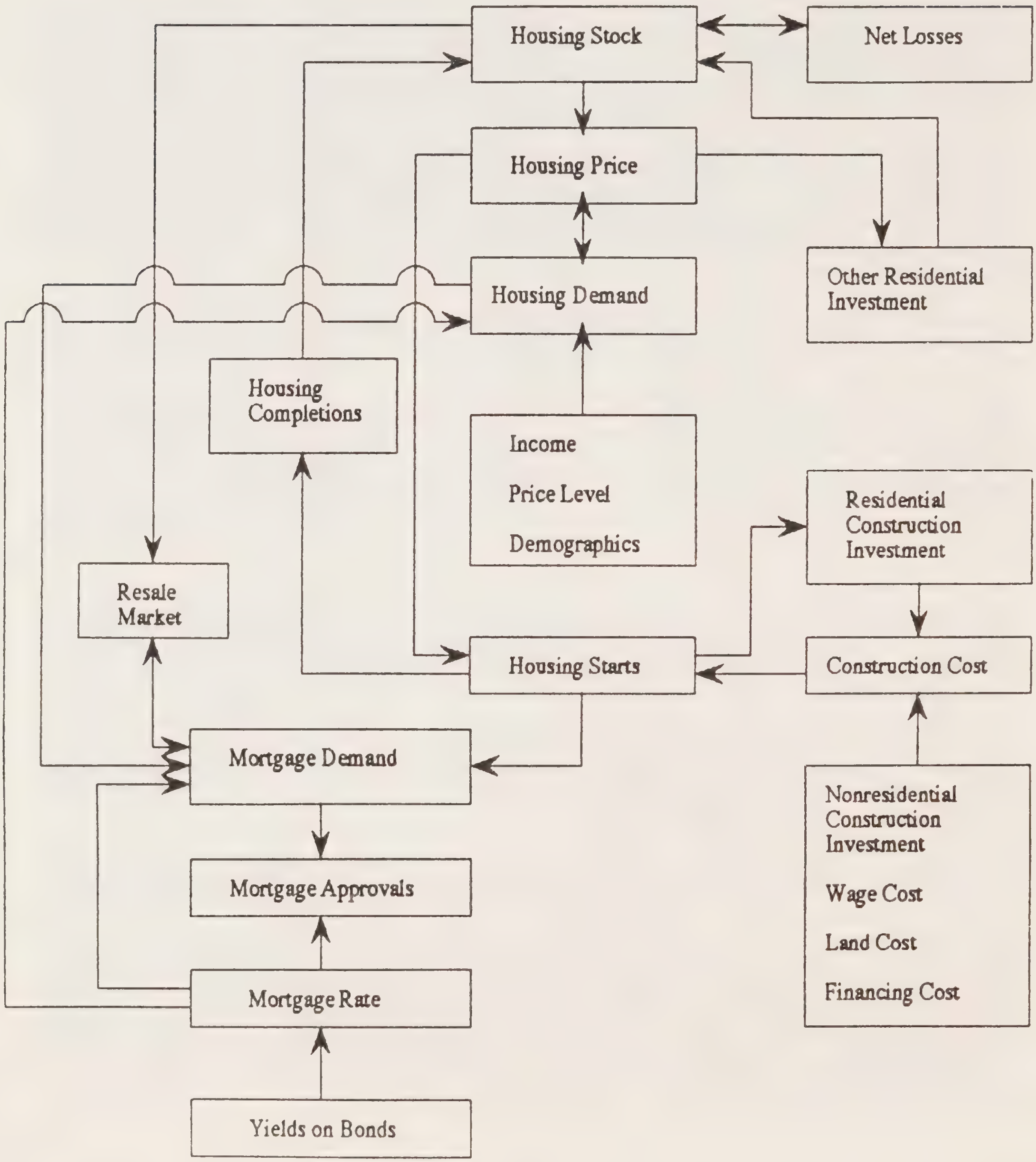
Housing starts depend on the expected profitability of housing construction given the housing price (and vacancies), the construction and land costs. Construction costs depend on the wage rate in the construction industry, the cost of bridge financing, and the current level of residential and nonresidential construction relative to the industry capacity. Land costs are determined primarily by the demand for residential land. The demand in turn depends on demographic variables, permanent income, and the existing stock of housing units. Clearly, mortgage costs and the availability of conventional and NHA mortgage credit affect housing starts as well.

The mortgage market side of the model is represented at the bottom of the diagram. The demand for mortgage credit is derived from the housing demand, and thus depends essentially on the same factors as the demand for housing plus the cost of financing, i.e., mortgage rate. The supply of mortgage credit is assumed to be infinitely elastic so that institutional mortgage approvals would depend primarily on the demand for mortgage credit. The mortgage rate itself is explained by the yield obtainable on alternative investment (say, bond yields).

Figure 1.1 below simplifies the structure of the model by not maintaining the distinction between the single-family and multi-family dwellings. Recognizing that participants in the two subsectors of the housing market are different in their behaviour, we maintain the distinction in housing units between the single and multiple dwellings in the housing market modelling. Housing starts, housing completions, and investment in new residential construction are disaggregated further by the structure type: single-detached, semi-detached, row housing and apartments.

FIGURE 1.1

FLOW DIAGRAM OF THE MODEL



2. The Housing Sector Model

2.1 Introduction

Section 2.2 presents the conceptual framework for a macroeconomic model of the Canadian housing market. Section 2.3 discusses the data series used in estimating the model. Section 2.4 presents the results of efforts to estimate the model and Section 2.5 uses the model to forecast housing variables for 1991, as well as simulation results for the period 1972 to 1991.

2.2 Conceptual Framework for the Housing Market Model

The basic paradigm is a variation of the traditional "stock-flow" model of the housing market. According to this model, at any given time housing prices are determined by the existing stock of housing and the demand for housing services.[1] In turn, the expected profitability of housing construction given the relative price of housing and the costs of new construction determines the flow of new housing construction. The modelling approach outlined here draws heavily upon recent efforts by DiPasquale and Wheaton (1990) and (1991) to model both the owner and rental housing markets in the United States.

The housing market model outlined below divides into two components. One system of equations estimates the supply and demand for single family housing, while another system of equations estimates the supply and demand for multifamily housing. This distinction recognizes the fundamental difference in the financial returns associated with these different types of housing and therefore the different incentives for their production. Specifically, the model assumes that single family housing is owner occupied while multifamily housing is occupied by renters.

Obviously this assumption is a simplification of actual tenure patterns. Data from the 1986 Census found that 10.5% of single family units were rented while 25.8% of multifamily units were owner-occupied. In light of the growing importance of multifamily for-sale housing and the significant number of renter occupied single family homes, it would be preferable to separate the housing

---

[1]Because of the lack of data on the value of the nation's housing stock, and hence the total value of housing services, we will follow the standard practice of assuming that each housing unit yields a unit of housing services and that the supply and demand of housing services is equivalent to the supply and demand for the housing stock.

stock into owner-occupied and rental housing for both the single family and multifamily markets.

Unfortunately, the lack of historical data of housing stock and housing prices by tenure and structure type, as well as data on new construction by intended use (e.g. for sale or for rent), make joint modelling of structure type and tenure impossible. Given the limitations of existing data and the fact that almost 90% of single family houses are owner-occupied and 75% of multifamily homes are renter-occupied, the use of structure type as a proxy for tenure is commonly used in housing market models. It is also to be noted that social housing has not been split out from market housing due to severe data irregularities.

This section contains four parts. Sections 2.2.1 and 2.2.2 present details on the theory underlying the demand and supply equations for this stock adjustment model. Section 2.2.3 discusses the model of the resale market for existing homes. Finally, Section 2.2.4 discusses the role of housing stock conversions and housing inventory losses in the context of a housing stock adjustment model.

2.2.1 Housing Demand

Based on the accumulated evidence of previous housing market studies, the primary exogenous factors determining the demand for housing include real income and the size of the population and the age and demographic characteristics of the population. The endogenous factors that determine demand include the cost of housing, household formation, and housing prices. The methods employed to estimate these endogenous factors are discussed below.

Housing Costs: Since single family housing is both an asset and a consumer good, the estimated cost of housing must take into account both of these aspects of the good. Following the method used by Hendershott and Shilling (1982) and DiPasquale and Wheaton (1991), equation (2.1) presents an estimate of a user cost of capital for owner-occupied housing:

$$OC = MI - PE \tag{2.1}$$

where: OC = owner-occupant's user cost of capital
MI = mortgage interest rate
PE = expected rate of housing price appreciation

Equation (2.1) essentially adjusts the mortgage interest rate to reflect the financial return from housing price appreciation. Because interest and property tax payments are not tax deductible in Canada, equation (2.1) is much simpler than in models of the U.S. housing market. The owner's cost of capital could also be adjusted to include annual property tax and maintenance rates, but since no timely data on these rates exist they would enter the

equation as a constant and so their exclusion should not affect the estimated equation. The owner's cost of capital together with the price of housing represent total housing costs for homeowners.

An important aspect of equation (2.1) is the expected appreciation in housing prices. DiPasquale and Wheaton (1991) have investigated two approaches for modelling how consumers form expectations about house price appreciation. One assumes that expectations are developed by "looking backward" at recent historic price appreciation trends, while the second method is based upon rational "forward-looking" forecasts based on instrumental variables. Both of these approaches will be explored in developing the model of the Canadian housing market.

For renters, the cost of rental housing, or gross rent, is simply the sum of contract rent payments and other out-of-pocket housing expenses. Contract rent is the monthly payment to the property owner for housing services; gross rent includes not only contract rent, but also payments for fuel, water, sewerage, and other utilities. Depending on the agreement between the tenant and the property owner, the tenant may pay the property owner only the rent for the structure itself, or may make an additional payment to the property owner to cover heat and other items that are included in the measure of gross rent.

<u>Household Formation:</u> The number of households is of fundamental importance in determining housing demand. Since the cost of housing influences the choice of individuals and families to form an independent household, the number of households should be an endogenous variable in a model of the housing market. In addition to housing costs and demographic factors such as the age distribution of the population, the divorce rate and female labour force participation rates, and income level by age groups also appear to influence household formation rates. [Smith, Rosen, Markandya and Ullmo (1984) and Borsch-Supan (1986)]. Since quarterly estimates of income by age group are not available, estimates of household formation by the methods outlined in the above cited papers will not be possible.

Following DiPasquale and Wheaton (1990), the modelling exercise explored an alternative method for estimating household formation. Applying age specific headship rates (or the proportion of any given population age group forming independent households) from a given base year to the age distribution of the population in each quarter produces an "age-expected" number of households. DiPasquale and Wheaton propose substituting this "age-expected" household series for estimates of actual households in the stock adjustment framework. Since "age-expected" household captures the effect of demographic factors on household formation, the difference between the "age-expected" and actual households measures the extent to which changes in income, prices, and other economic variables influence household formation. Wheaton and

DiPasquale argue this approach eliminates the need for detailed time series data on actual households by age and income level, yet nevertheless allows for the joint estimation of household formation and the housing stock demand.

<u>Demographic Trends:</u> Changes in the age structure of the population and households exert a fundamental influence on the demand for housing. As the proportion of the households headed by those in age groups with the highest home ownership rates increase, so will the demand for single family housing. Of similar importance are changes in the types of households formed. Specifically, since family households have higher homeownership rates than non-family households, the trend toward fewer family households among all age groups will affect housing demand. Again following Wheaton and DiPasquale (1990), changes in both the age structure of the population and household types will be included in the model by an age-expected ownership rate that is analogous to the age-expected household concept discussed above. To estimate the expected ownership rate for the nation, the ownership rate for each age group and household type (family and non-family) from a given base year is applied to the age distribution of the household population in each quarter.

<u>Determination of Single Family Housing Prices:</u> The specification of the housing demand equation includes the demographic and housing cost variables discussed above. Government housing programs designed to spur demand for single family housing are also included in the model through construction of a series of dummy variables. As shown, equation (2.2) provides for an interaction between the number of households and the other demand variables:

$$HH_t[B_0 + B_1YPD_t + B_2PH_t + B_3OC_t + B_4OR_t + B_5PR_t + B_6GOVT_t] = KHS_t \tag{2.2}$$

where:
HH_t = number of households in quarter t;
YPD_t = real disposable income per household in quarter t;
PH_t = real single family housing price in quarter t;
OC_t = owner-occupant's housing cost in quarter t;
OR_t = age-expected home ownership rate in quarter t;
PR_t = real rental housing price in quarter t;
$GOVT_t$ = dummy variables representing government programs in quarter t;
KHS_t = single family housing stock in quarter t;

The term within the brackets in equation (2.2) may be interpreted as the fraction of households that choose to live in single family housing. As discussed above, if the age-expected household population is substituted for the actual number of households in equation (2.2) then the term in brackets estimates the fraction of estimated households that actually form <u>and</u> also choose to live in single family housing. To the extent that income and housing prices influence both household formation and housing stock demand,

this formulation permits joint determination of these two separate effects.

The expected sign of the coefficient on the price variable (B_2) is negative, since the demand for single family housing should decline as the price of housing rises. Similarly, as the user cost of housing increases, the demand for housing should decrease, and hence, the coefficient on the user cost variable (OC) should be negative. On the assumption that multifamily housing is a substitute good for single family housing, as the rental housing price increases the demand for single family housing should increase and the expected coefficient on the rental price variable (PR) is positive.[2] While there is no strong theoretical presumption for the effect of a change in real incomes on the demand for owner-occupied housing, in most studies of tenure choice the income variable (YPD) is positive [Rosen and Rosen (1980)]. Finally, as the expected ownership rate increases, the demand for single family housing will also increase. Thus, the expected coefficient on the age-expected ownership rate (OR) is positive.

Solving equation (2.2) for the market clearing housing price yields equation (2.3):

$$PH_t = 1/B_2[KHS_t/HH_t - B_0 - B_1YPD_t - B_3OC_t - B_4OR_t - B_5PR_t - B_6GOVT_t] \qquad (2.3)$$

The traditional stock-flow model as represented in equation 2.3 assumes that prices quickly adjust to their equilibrium level. However, there is reason to believe that housing prices adjust only gradually in response to shocks. DiPasquale and Wheaton (1991) note that given the heterogeneity of housing and the resulting lengthy search process, the anticipated sales time for a home can be long and show great variation. As a result, sellers cannot determine whether an unusually long sales time represents a decline in the market or simply random misfortune. In this context rapid price adjustments may not be rational. Other researchers have noted that the decision to change the consumption of housing may be subject to lengthy lags due to high transaction and search costs and since this decision is often linked to other life cycle factors such as marriages, births, or deaths [Rosen and Rosen (1980)].

Equation 2.4 depicts the price adjustment process in terms of a single period lag. At any point, current period price depends on both the unobserved current period equilibrium price and the actual price observed in the previous period.

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[2] Since households choose between consuming housing services and other goods and services the price variables for both single and multifamily housing will be measured in real terms in order to measure their movement with respect to the price of all other goods and services.

$$PH_t = \tau PH^*_t + (1 - \tau) PH_{t-1} \tag{2.4}$$

where: PH_t = actual real price in quarter t;
PH^*_t = equilibrium real price in quarter t;
τ = rate at which PH_t converges to PH^*_t; and
PH_{t-1} = actual real price in quarter t-1.

Recalling that equation (2.3) depicts the equilibrium price that flows from the stock adjustment framework, equation (2.5) combines equation (2.3) with equation (2.4) to incorporate the assumption of gradually adjusting prices into a basic stock adjustment model of the housing market.

$$PH_t = \tau\ [1/B_2\ [KHS_t/HH_t - B_0 - B_1YPD_t - B_3OC_t - B_4OR_t - B_5PR_t - B_6GOVT_t] + (1 - \tau) PH_{t-1} \tag{2.5}$$

While this specification lacks a choice-theoretic foundation, the findings of DiPasquale and Wheaton (1991) indicate that the specification of a model which incorporates gradual price adjustment may produce more satisfactory results than one which assumes that prices adjust immediately to the equilibrium price.

<u>Determination of Cost of Rental Accommodations:</u> Similar to single family housing, factors such as the number and age distribution of households, real disposable income, and rental housing price levels should influence the demand for multifamily housing.

One common approach to modelling market rents is to assume that changes in rental prices are determined by the difference between the current vacancy rate and the market's structural or normal vacancy rate. The assumption is that rental markets require some vacancies to accommodate mobility or rental units turnover. Because of the existence of rental contracts, it is also often assumed that prices cannot immediately adjust to new market conditions and so rents gradually move to new equilibrium levels.

However, because good quality vacancy data are often not available and because there are several troublesome issues in determining changes in rental prices based on vacancy rates, this study employs a variant of the stock adjustment model presented earlier to determine market equilibrium rents. The equation estimating demand for rental housing is identical to that used to model single family home prices.

$$HH_t[B_0 + B_1YPD_t + B_2PH_t + B_3OC_t + B_4OR_t + B_5PR_t + B_6GOVT_t] = KHM_t \quad (2.6)$$

where:
HH_t = number of households in quarter t;
YPD_t = real disposable income per household in quarter t;
PH_t = real single family housing price in quarter t;
OC_t = owner-occupant's housing cost in quarter t;
OR_t = age-expected home ownership rate in quarter t;
PR_t = real rental housing price in quarter t;
$GOVT_t$ = dummy variables representing government programs in quarter t; and
KHM_t = multifamily housing stock in quarter t.

As in the case of single family housing, the term within the brackets in equation (2.6) may be interpreted as the fraction of households that choose to live in multifamily housing. As discussed above, if the age-expected household population is substituted for the actual number of households in equation (2.6), then the term in brackets estimates the fraction of estimated households that actually form and also choose to live in multifamily housing. To the extent that income and housing prices influence both household formation and housing stock demand, this formulation permits joint determination of these two separate effects.

The expected sign of the coefficient on the real rent variable (B_2) is negative, since the demand for multifamily housing should decline as rents increase. Similarly, as the price of single family homes (PH) or the user cost of owner-occupied housing (OC) increases, the demand for multifamily housing should increase, as multifamily housing and single-family housing are assumed to be substitute goods.[3] While there is no strong theoretical presumption for the effect of a change in real incomes on the demand for rental-occupied housing, most studies of tenure choice show that income (YPD) is inversely related to the share of households choosing rental accommodations.

Solving equation (2.6) for the market clearing rent level yields equation (2.7):

$$PR_t = 1/B_2[KHM_t/HH_t - B_0 - B_1YPD_t - B_3OC_t - B_4OR_t - B_5PH_t - B_6GOVT_t] \quad (2.7)$$

Similar to the equation for the demand of single family housing, the household term in equation (2.7) interacts with the other

---

[3]Since households choose between consuming housing services or other goods and services the price variables for both single and multifamily housing will be measured in real terms in order to measure their movement with respect to the price of all other goods and services.

factors that determine demand in order to estimate the number of households that choose to live in multifamily housing. As mentioned above, the existence of rental contracts may inhibit the immediate movement of rents to new equilibrium levels. In order to test for a gradual price adjustment process in the rental market, equation (2.8), similar to equation (2.5) for the single family market, will also be estimated.

$$PR_t = \tau \; [1/B_2 \; [KHM_t/HH_t - B_0 - B_1YPD_t - B_3OC_t - B_4OR_t - B_5PH_t - B_6GOVT_t] + (1 - \tau)PH_{t-1} \tag{2.8}$$

Obviously, the use of rent control in Canadian markets will inhibit changes in rental rates and so this factor will also have to be taken into account in modelling changes in rents. Dummy variables will be constructed to reflect the time periods and geographic regions that were subject to rent control.

2.2.2 Housing Supply

The expected profitability of housing construction given the relative price of housing and the costs of new construction determine the flow of new housing construction, or housing starts. The housing demand equations specified above will be used to estimate the price of housing. This section presents the other factors that influence the supply of new housing and outlines the conceptual framework that will serve as the basis for estimating new housing starts.

<u>Single Family Housing Starts:</u> The volume of new single family housing starts can be estimated as a function of the price of housing and various construction cost factors. The primary construction costs include those for construction materials and labour, land, and financing. In addition, builders are likely to be cognizant of economic and demographic trends that will affect the demand for their product. Thus, measures of economic and demographic growth are likely to serve as signals for builders to construct new housing and so will also be included in the estimated equation. The housing starts equation will thus be of a form similar to equation (2.9):

$$HSS_t = B_0 + B_1PH_t + B_2I_t + B_3L_t + B_4C_t + B_5D_t + B_6E_t \tag{2.9}$$

where:
HSS_t = single family housing starts in quarter t;
PH_t = real single family housing price in quarter t;
I_t = real construction financing rate in quarter t;
L_t = real land price in quarter t;
C_t = real construction costs in quarter t;
D_t = demographic growth measures in quarter t; and
E_t = economic growth factors in quarter t.

In modelling quarterly housing starts it will also be necessary to include dummy variables for the time of year in order to account for seasonal variations in construction activity.

As the cost of construction, as measured by the interest rate, land price, and construction cost variables increase relative to the price of housing, the profitability of new construction will decline, as will housing starts. As a result, the coefficients on these variables are expected to be negative. Conversely, as the price of housing increases the profitability of new construction, and hence housing starts, will increase. Thus, the coefficient on the housing price variable is expected to be positive. Since both economic and demographic growth signal increases in household formation and thus the demand for housing, the expected coefficients on these variables are expected to be positive.

Multifamily Housing Starts: The level of new multifamily housing construction will depend on the profitability of rental housing given the price of rental housing services, construction cost levels, the market vacancy rate, and the cost of capital. Analogous to the owner's cost of capital depicted in equation (2.10), the rental cost of capital modifies the mortgage rate by the expected appreciation rate of rents and income tax regulations to estimate a net cost of capital for apartment owners.[4] This variable can also be used to capture the effect of government programs designed to spur the production of multifamily housing. By either altering the tax treatment of income and costs or providing a subsidy to the project, government programs will change the rental cost of capital. The rental cost of capital can also capture the financial effects of rent control regulations to the extent that the regulations actually limited the growth of rents. A dummy variable reflecting the time periods and geographic regions that were subject to rent control may also be included to measure the extent to which rent controls had a chilling effect on multifamily development activity beyond their impact on market rent rates.

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[4]The calculation of the rental cost of capital is more complex than that for single family homeowners since it takes into account the annual taxation of rental income and deductions for depreciation as well as capital gains taxation at the time of sale. The calculation involves information on tax rates on income, capital gains, and real property, depreciation rates for tax purposes, mortgage rates for multifamily investors, and recent inflation in rent levels as a measure of expected future growth in rents. In addition, the calculation assumes that properties are held on average for 10 years and that the economic depreciation of rental property is 1.5% per year. For a detailed description of the specific formulation of the rental cost of capital see DiPasquale and Wheaton (1990) pp. 13-15.

As with the single family home market, multifamily builders may look to demographic and economic growth factors as signals of housing demand and so variables reflecting these factors will also be included. Equation (2.10) presents the expected form of the supply equation for multifamily housing.

$$HSM_t = B_0 + B_1R_t + B_2V_t + B_3RCAP_t + B_4C_t + B_5D_t + B_6E_t \tag{2.10}$$

where:

HSM_t = multifamily housing starts in quarter t;
R_t = real rental price in quarter t;
V_t = rental vacancy rate in quarter t;
C_t = real construction costs in quarter t;
$RCAP_t$ = real rental cost of capital in quarter t;
D_t = demographic growth measures in quarter t; and
E_t = economic growth factors in quarter t.

Equation 2.10 will be estimated separately for the three structure types comprising multifamily housing: apartments, semi-detached and row housing.

As with single family housing starts, a dummy variable for the time of year will also have to be included in order to account for seasonal variations in housing starts.

Since increases in the vacancy rate (V), construction costs (C), or the rental cost of capital (RCAP) reduce the profitability of multifamily housing, the coefficients on these variables are expected to be negative. Conversely, increases in the rental price (R) increase the profitability of new construction and so the coefficient on this variable is expected to be positive.

2.2.3 Housing Resale Market

The model of existing homes prices sold through the multiple listing service expands on the methods outlined in Section 2.2.1 above with regard to the price of single family homes. The model of the level of existing home sales is based on the conceptual framework outlined by Rosen and Smith (1986). According to this model, the <u>level</u> of home sales depends on <u>changes</u> in the factors which determine the household demand for housing services such as those listed in equation (2.3) above. In essence, changes in demand factors produce a disequilibrium between the desired and actual quantity of housing services consumed. The disequilibrium occurs because there are very large transaction costs associated with selling a home and moving. As a result, the model should also include factors related to the transaction costs associated with moving. When the disequilibrium is great enough to overcome the transaction costs associated with moving, or when these transactions costs decline, the household will adjust their housing consumption by moving. Relatively sharp changes in either the

factors that determine demand or transaction costs will increase the level of disequilibrium between desired and current housing consumption and thus increase the probability of a move.

The specific factors influencing the demand for housing services include household income, the price of housing, the expected appreciation in housing values, changes in the mortgage rate, and demographic factors. The factors influencing the transaction costs of altering the quantity of housing services consumed include costs related to moving, such as the mortgage rate (since households must renegotiate current housing debt at prevailing mortgage rates), and the volume of new housing completions (as a measure of the availability of alternative housing). In addition, households can change their housing consumption by remodelling their current home. Thus, costs related to modifying the household's current house by alterations and additions, such as construction costs should also be included.

Basing their model on the decision of an individual household, Rosen and Smith scale changes in the above factors by the total number of households to estimate the total volume of housing sales. Alternatively, the number of households can be included as an independent variable to scale the number of home sales over time. Equation (2.11) summarizes this conceptual framework:

$$MLSS_t = B_0 + B_1DYPD_t + B_2DDEM_t + B_3DPH_t + B_4DRM_t + B_5DHCS_t + B_6DC_t + B_7DPE_t + B_8PR_t + B_9HH_t \qquad (2.11)$$

where:
$MLSS_t$ = Multiple Listing Service sales in quarter t;
$DYPD_t$ = change in real disposable income per household in quarter t;
$DDEM_t$ = change in demographic factors in quarter t;
DPH_t = change in real single family house price in quarter t;
DRM_t = change in real conventional mortgage rate in quarter t;
$DHCS_t$ = change in single family completions in quarter t;
DC_t = change in real construction costs in quarter t;
DPE_t = change in real expected house price growth in quarter t;
DPR_t = change in real rental price in quarter t; and
HH_t = household population in quarter t.

2.2.4 Housing Stock Adjustments

The stock of both owner and rental housing is incorporated in the demand and supply equations presented above. The housing stock at any given time is a function of the housing stock in the previous time period adjusted for additions to the stock through new housing

completions, the subdivision of existing units, and the conversion on non-residential buildings to residential use, as well as removals due to the merger of existing units, the conversion of existing units to non-residential uses, or demolition.

There is extensive theoretical literature on the determinants of inventory losses and inventory conversions [Kain and Apgar (1985)]. Housing capital is durable and fixed in location. Within any local housing market, there will be distinct housing submarkets defined both by the type of housing provided and the characteristics of households served. While housing submarkets are linked in the sense that households can move from one submarket to the next, they are not perfectly linked. Thus it is possible for there to be persistent excess supply of dwelling units in one submarket (e.g. new efficiency apartments in large multi-family structures) and persistent excess demand for units of another type (e.g. lower quality, three-bedroom apartments in small wood-frame structures).

In the short run, geographically specific excess supply or excess demand of units of a given tenure or structure type will yield changes in market rents and/or the market value of individual dwelling units. Over time, these price changes will trigger both changes in household demand and housing supply as the market seeks to restore equilibrium. Persistence of excess supply of rental units and low rents, for example, will eventually trigger disinvestment in the existing housing stock of rental housing. This may come in the form of conversion of larger, higher quality units to lower quality and/or smaller units, or conversion to non-residential uses. Absent a profitable conversion option, persistent excess supply and disinvestment will eventually lead to the withdrawal of units from the inventory, though the process of inventory removal may take years.

Conversely, persistent excess demand in a particular submarket will not only provide incentives to build new units, but also encourage property owners to convert less profitable residential and non-residential properties to serve this demand. Thus, the surge of demand for owner-occupied housing may result not only in the increased construction of new single family or multifamily for sale housing, but also stimulate condominium conversion or the adaptive reuse of non-residential space into lofts or other types of owner-occupied housing.

Though housing market theory strongly suggests that inventory losses and conversions are endogenously determined, data limitations preclude their inclusion in a macro-economic model as consistent measures of inventory loss and conversion are not available for Canada over time. Absent these data, the housing stock adjustment market model presented below could not separately model these components. Instead, two separate approaches were taken to link housing starts to changes in housing stock. The first approach follows [Hendershott and Smith (1988)]. Equation

(2.12) summarizes the relationship between changes in the single family housing stock and single family housing starts:

$$KHS_t = B_1KHS_{t-1} + B_2HSS_{t-1} + B_3HSS_{t-2} + B_4HSS_{t-3} + B_5HSS_{t-4} \quad (2.12)$$

where:

KHS_t = single family housing stock in quarter t; and
HSS_t = single family housing starts in quarter t.

The coefficients on the lagged housing starts variables estimate the proportion of housing units started in previous quarters that are completed in the current quarter. The number of lagged quarters to include in the equation should reflect the longest period of time that would be expected to complete a housing unit, with the most appropriate number of quarters to include to be determined by the empirical results. The sum of coefficients on the lagged housing starts should be equal to the proportion of all starts that are completed, which should be very close to one.

The coefficient on the lagged housing stock variable represents the net rate at which the stock changes due to means other than new construction, including the subdivision and merger of existing units, the conversion of units from or to non-residential uses, and demolitions. Since the stock of housing changes very slowly this coefficient should be close to one. If net additions outweigh net losses to the stock the value will be greater than one, while if net losses outweigh net additions the value will be less than one.

In effect, this equation estimates net losses from the long term historical relation between changes in housing stock and housing starts. Unfortunately, theory suggests that the net loss rate is not constant overtime, but will vary more or less gradually depending on the relative profitability of the various conversion activities described above.

Moreover, this specification places considerable weight on the assumed accuracy of historical estimates of housing stock by type. Examination of implied net loss rates that flow from comparing total stock over a given period with completions for the same period do little to inspire confidence in the historical stock estimates. Apparently, the problem is embedded in the methods used to estimate annually the housing stock and the number of households. Since total stock and total household estimates are periodically benchmarked to the Canadian Census, differential Census undercounts imbed bias in the housing stock estimates over time that cannot easily be eliminated. As a result, the implied net loss rates that emerge from the comparison of stock change and completions seem to be more influenced by the timing of the Canadian Census, than they are influenced by economic events.

Recognizing these limitations, an alternative approach divides equation (2.12) into two parts. First, equation (2.13) estimates

the relation between starts and completions.

$$HCS_t = B_1HSS_t + B_2HSS_{t-1} + B_3HSS_{t-2} + B_4HSS_{t-3} \tag{2.13}$$

where: HCS_t = single family housing completions in quarter t;
HSS_t = single family housing starts in quarter t.

The use of four quarters of lagged starts implies that single family homes take at most one year to construct. The most appropriate lag structure can be explored through empirical estimation of this equation.

Similarly, multifamily completions can be estimated from lagged multifamily starts. Equation (2.14) presents the multifamily equation. A slightly longer lag structure is indicated because of the longer time span needed to complete construction of these larger structures. As with the single family equation, empirical estimation will determine the most appropriate lag structure.

$$HCM_t = B_1HSM_t + B_2HSM_{t-1} + B_3HSM_{t-2} + B_4HSM_{t-3} + B_5HSM_{t-4} \tag{2.14}$$

where: HCM_t = multifamily housing completions in quarter t;
HSS_t = multifamily housing starts in quarter t.

The multifamily completion equation will be estimated separately for each multifamily structure type: apartments, semi-detached, and row housing.

Next, equations (2.15) and (2.16) combine the estimated housing completions with exogenously specified estimates of the net loss rate to produce the following identities for single family and multifamily housing stock:

$$KHS_t = LR_s{*}KHS_{t-1} + HCS_t \tag{2.15}$$

$$KHM_t = LR_m{*}KHM_{t-1} + HCM_t \tag{2.16}$$

where: LR_s = net loss rate of single family stock; and
LR_m = net loss rate of multifamily stock.

As an exogenous factor, choice of net loss rate can be established by forecasters using the model. Possible choices would be to use loss rates derived from independent estimates, or even use some version of a loss rate recovered from the historical data by a regression estimation of equation (2.12) with the loss rate given by the coefficient on the lagged housing stock variable. In any event, while this alternative approach does address problematic data issues, it does in effect make new housing construction of single-family and multifamily housing the only endogenously determined form of housing stock adjustment present in the model.

2.3 Data Series

This section describes the data series that will be used to estimate the econometric model of the Canadian housing market.

Consumer Price Index: This study uses the all items consumer price index (CPI) to express prices, costs, interest rates, and incomes in inflation adjusted terms. Although widely used, the CPI index has known flaws, most notably bias introduced by failure to properly measure homeowner costs.[5] The CPI homeowner's cost measure is defined to be the sum of several ongoing expenses (including outlays for mortgage interest payments, fuel and utility costs, maintenance and repairs, real estate taxes and insurance). As noted in the housing literature for both the United States and Canada, such cash cost measures substantially overstate the total cost of homeownership, particularly to the extent that equity buildup, or increases in the value of owner-occupied housing, serve to offset the high cash costs of ownership during periods of high overall inflation. Since homeowner costs are a major component of overall CPI, the bias in the measurement of homeowners costs also biases the overall CPI as well.

Lacking sufficient data to correct the Canadian CPI data for this problem, this study explored the use of alternatives to the Consumer Price Index. Deflating by the Personal Consumption Expenditure Component of Gross Domestic Product or the All Items Less Shelter Component of CPI would theoretically correct for the problem, but given the widespread use of the CPI, the effort to identify a more appropriate deflator for modelling purposes was abandoned.

Single Family Housing Price: The model uses two housing price series.[6] The first series is the New House Price Index (NHPI) produced by Statistics Canada. This series begins in 1971, but underwent fundamental changes in the geographic scope of the survey and the methodology used to estimate the index in 1976 and 1981. A single series was constructed for this project covering these three different time periods using a linking methodology suggested by Statistics Canada. The same methodology was also used to link the land price component of this index for the period from 1976 to the present.

The second price series is the average sales price of homes sold

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[5]See "An alternative measurement of housing costs and the Consumer Price Index" by Stuart McFadyen and Robert Hobart, Canadian Journal of Economics, February 1978.

[6]Issues related to the quality and suitability of these two price series will be discussed in connection with the Estimation Results in Section 2.4.

through the Multiple Listing Service (MLSP). A quarterly series for the period from 1977 to the present was constructed from a monthly data series. Prior to 1977 a quarterly series was interpolated from data on annual average sales prices.

Unfortunately, both these series have significant flaws that undermine their usefulness in the modelling of a housing market. The stock adjustment framework, as well as other basic theories of housing market dynamics, assert that the price for housing of a given <u>quality</u> will respond to a number of factors that influence the supply of and the demand for housing. Empirical estimation of the parameters of a stock adjustment model, or indeed any model of housing supply or demand, require estimates of the market price of housing of constant quality.

Recognizing that housing is a particularly complex good, difficulty in developing appropriate "constant quality housing price indices" for either new or existing homes has generally limited development of housing market models in the United States and other countries. Canada is no exception. As described above, national housing price indices have undergone numerous changes over the past two decades, as researchers at Statistics Canada and CMHC, among others, sought to develop appropriate measures of housing prices.

Currently, the best available measure of constant quality house prices appears to be the New Home Price Index (NHPI) produced by Statistics Canada. As indicated in Figure 2.1, after adjusting for inflation by the all items measure of CPI, the New Homes Price index moved up rapidly in the early 1970s, only to fall equally rapidly in the late 1970s and early 1980s. Indeed, from the first quarter of 1976 to the first quarter of 1984, the inflation adjusted price declined by 35 percent.

While rapid price fluctuations of this magnitude are possible for individual submarket areas, movements of this magnitude on a national basis are unlikely. Given the fact that the index combines data from metropolitan areas concentrated in high growth areas of the country, the NHPI may not be geographically representative of the existing housing stock. In addition, the volatility of this index may not stem from changes in the individual market areas included in the index as much as from changes in the regional distribution of housing construction activity. Unlike a "true" price index that reports changes in a fixed market basket of goods or services over time, the market basket of new homes used to build the NHPI changes over time as the regional distribution of housing construction changes. Rather than weight observed home price changes by a fixed set of regional weights, the NHPI varies the regional weights using a three year moving average of housing construction activity. As a result, the NHPI is not a true "constant quality price index," but more a measure of the average value of new homes built in Canada.

Equally problematic is the fact that significant movements in the NHPI prior to 1981 are not reflected by similar changes in the price of existing homes. While new home prices and existing home prices are not perfectly linked in the short run, over time they should move in the same direction. Persistent increases in the cost of building new homes (for example as a result of increases in the cost of new land available for construction), will increase the market value of homes already built. Alternatively, a substantial reduction in cost of new construction (for example as a result of a significant reduction in the cost of building materials) will over time result in a decrease in the market value of existing homes.

As shown in Figure 2.1 at the end of this chapter, the long term trends in the NHPI and the MLS average sales price (deflated by the all items consumer price index) do not conform to these basic theoretical expectations. Against substantial variation in new home prices during the late 1970s, existing home prices remained relatively stable. As noted earlier, the reported new home price index declined by 35 percent over the period 1976 to 1984, while the existing home price index declined by only 20 percent.

Despite the issues discussed above, the NHPI may be the best constant quality price index available for Canada. However, estimation of the stock adjustment model is to be accomplished with a price series for existing homes, since the model jointly determines market price and demand for the total housing stock, of which new homes represent only a small proportion. On the other hand, the average price of homes sold through the Multiple Listing Service covers the existing home market, but is subject to fluctuations in the types of homes sold due to seasonal and economic cycle variations as well as changes in the quality of the overall stock of existing homes over time.[7] Thus, neither of these series is well suited for use in the stock adjustment framework. Nonetheless, absent more suitable alternatives these series will be used to represent the price of new and existing homes respectively.

Rental Price: Statistics Canada's price index for rental accommodations will be used as the rent variable. While undoubtedly the best available measure of market rents, this measure is also not without flaws. As is the case with home price

[7]There are other issues related to the quality of each of these prices series as well. The NHPI series may be subject to a downward bias due to the methodology used to control for changes in the types of homes constructed by reporting builders. The MLS series reportedly includes commercial transactions prior to 1980. Both series are subject to variations over time in both the geographic area they cover as well as the proportion of the new and existing home market that they represent. Unfortunately, there does not appear to be any available remedy for these defects.

indices, a true price index tracks the price of a particular good or service of constant quality and characteristics. Given the importance of housing condition or quality as a determinant of rent, price indices for rental accommodations are difficult to construct. The addition of new units during periods of cyclical upturns undoubtedly raises the quality of the housing inventory in ways that are difficult to capture in rental price indices. Alternatively, during economic down cycles, dwelling unit depreciation is likely to lower average unit quality. As a result, some of the observed cyclical variation in rents reflects changes in the quality of rental units as opposed to changes in rents for units of constant quality.

Recognizing these problems, the U.S. Census Bureau has developed a method for correcting historical data for the bias introduced by these factors [Randolph (1988)]. Although no such correction is available for Canada, given the steady aging of the Canadian housing stock, it seems likely that the failure to adjust for quality effects will bias downward estimated long-term trends in Canadian rent levels.

Construction Costs: Indexes for the cost of construction labour and materials from Statistics Canada were used to construct a single construction cost index. A monthly series on construction labour costs beginning in 1971 was used to construct a quarterly labour cost index. Likewise, a monthly series on construction material costs beginning in 1981 was used to construct a quarterly material price index from 1981 to the present. Prior to 1981 only an annual construction materials index was available. A quarterly series was interpolated from this annual series based on the quarterly inflation pattern exhibited by the construction labour index. A quarterly total construction cost index series was then constructed based on the average weight used by Statistics Canada to form an annual total construction cost index during the period from 1971 to 1984.

Multifamily Vacancy Rate: The quarterly multifamily vacancy rate series is derived from the CMHC semi-annual series on the vacancy rate in apartment structures with six or more units. The quarterly series is derived by interpolating the vacancy rate between the quarters that are reported by Statistics Canada.

Unfortunately, this measure is not consistent with other available measures of vacancy. For example, comparison of CMHC's estimates of total rental stock with estimates of the number of renters produces a measure of total rental vacancy rates. Since the units in apartment structures with six or more units account for nearly 60 percent of the total rental stock, these two measures of vacancy should be highly correlated. This appears not to be the case, suggesting that one or both of these measures contains significant measurement error over time.

Equally problematic is the fact that the basic rent measure used in this study bears no apparent relationship to observed trends in rental vacancy. Conceptually, there must be some "normal" or "natural" rate of vacancy, that is a vacancy rate associated with stable rent levels for a given market area. Decreases in vacancy rates below this "normal" level should be associated with increasing rents, while increases in vacancy rates above this measure should result in decreasing rents (Rosen and Smith). As shown in Figure 2.2, this basic relationship does not appear to hold in Canada, at least when rents are measured by the rental component of the CPI and vacancies are measured only for apartments with six or more units.

Several explanations are possible. Rent control could so alter the rent-vacancy relationship as to overwhelm the simple correlation depicted by Rosen and Smith. Indeed, the effect of rent control policies on rent levels is one of the issues to be explored in the empirical section of this report. At the same time, recognizing that rent control measures were not in effect for the entire time period, and that rent control efforts vary substantially from one province to the next, the rent control explanation is not entirely satisfactory. Equally likely is that the downward bias in the rent measure described earlier, along with problems in consistently measuring vacancies over time, combine to mask the true relationship between rents and vacancy. To the extent that this is the case, the observed relationship among rents, vacancy and rent control will be poor predictors of likely future trends in this critical component of a housing market forecast.

<u>Housing Stock:</u> The single family and multifamily housing stock series is derived from CMHC estimates of the annual housing stock. This annual series is combined with quarterly data on housing completions to construct a quarterly housing stock series. The difference between the housing stock in a given year and the sum of the stock from the previous year and the housing completions from the intervening four quarters is assumed to be the net change in the stock due to demolitions, conversions to and from non-residential uses, and the subdivision or merger of existing units. This annual net change in the stock is prorated evenly over the intervening four quarters. A quarterly series on the occupied stock of single and multifamily units is also interpolated from CMHC's annual estimates of the occupied single and multifamily housing stock.

<u>Households:</u> The number of households is derived from CMHC annual estimates of the occupied housing stock. A quarterly household series is constructed by interpolating the quarterly change in households from this annual series.

<u>Age-Expected Ownership Rate:</u> The age-expected ownership rate is calculated by applying the ownership rate by age group and household type (family and non-family) from the 1976 Census to a

quarterly estimate of the number of households in each group. In turn, the quarterly household by age group and household type estimates are derived by interpolating between the Census data available every five years on the number of households in each group. For the period since 1986, annual estimates of households by age group and household type from CMHC were used. For the rental demand equations the age-expected renter rate is simply one minus the age-expected ownership rate.

Age-Expected Households: The age-expected number of households is calculated by applying the headship rate by each age group from 1971 Census data to quarterly estimates of the population by age group. In turn, the quarterly estimates of population by age are calculated by interpolating the between the Census data available every five years on the population by age. For the period since 1986, annual estimates of population by age group from CMHC were used.

2.4 Estimation Results

This section presents empirical estimates of the econometric model of the Canadian housing market outlined above. In each equation the price and income series have been adjusted by the all-items consumer price index (CPI) in order to account for changes in the relative prices of other goods and services.[8] Similarly, unless otherwise noted, the mortgage rate series has been reduced by the annual inflation rate as given by the CPI all-items index.

2.4.1 Single Family Housing Demand

As described in Section 2.2.1, the factors related to the demand for the housing stock are used to estimate housing prices. Ideally, the price series used in this stock-demand model would be for constant-quality, existing homes. Unfortunately, neither the Statistics Canada New House Price Index (NHPI) nor the Multiple Listing Service Price (MLSP) series possesses the desired features. Lacking a clear choice, this section presents separate estimates of the stock-demand model for both the NHPI and the MLSP.

In each of the equations presented below, the owners cost variable has been estimated using backward-looking expectations for future home price changes as described in Section 2.2.1 above. Various lag structures of past price changes were explored with the most significant results provided by the percent change in home prices

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[8]These deflated series will be denoted by adding "/CPI" to the series name. It should be noted that the deflated series are also multiplied by 100 so they remain on the same 1986=100 base as the undeflated series.

from four quarters ago. Attempts to estimate an owners cost variable using forward-looking rational expectations based on an instrumental variable estimation of future home price changes did not yield significant results. The income series, personable disposable income, as used in estimating the equations is the sum of income in the current and three previous quarters to create an income series that is free of seasonal fluctuations. This series is then divided by the number of households (HH) to yield a per household income series. These adjustments represent both an effort to correct for seasonal variation in income, as well model the effect of "permanent," as opposed to "transitory" income on housing demand.

The coefficient on the age-expected home ownership rate, a variable created to capture changes in housing demand due to changes in the age structure of the population, was consistently negative. The sign of this coefficient should be positive, since increases in the proportion of the population in age categories with high homeownership rates should be associated with stronger single family housing demand. Since the results did not conform to prior expectation this variable was eliminated from the model. However, in order to account for the important role that demographic growth plays in housing demand, various measures of population growth were introduced into the price equations. Measures of demographic growth did not yield positive and significant coefficients in the NHPI equation, but the percent change in population (PPOP) is significant in the MLSP equation.

In addition, the coefficient of the consumer price index for renter accommodations (CPIRA) was consistently insignificant and so this variable was also eliminated from the preferred specification. The lack of correlation between this variable and single family home prices seems to imply that rental housing is not a close substitute for homeownership. Alternatively, the failure of the rent variable to enter with the expected sign could reflect price distortions in the rental market due to rent controls which defy our attempts to model these regulations. Finally, it is also possible that the lack of correlation is due to the questionable quality of these data series as discussed above.

Efforts to simultaneously estimate household formation and housing stock demand using the age-expected household concept did not yield satisfactory results. As a result, actual households are used in the preferred specification, implying that household formation is exogenous to the model.

Dummy variables were also included in the model to represent the effect of public programs on housing demand. Separate program dummies were developed to depict the operation of the Registered Home Ownership Savings Plan, the Canadian Home Ownership Stimulation Program, and the Canadian Mortgage Renewal Program. Though occasionally inclusion of these dummies yielded coefficients

with the expected sign, these coefficients were never statistically significant and so the program dummy variables were excluded from the preferred equations.

Equations estimated with lagged housing prices as an independent variable (as specified in equation 2.5) based on the assumption that the market adjusts gradually to new equilibrium levels greatly improved the model's performance in simulations and so were chosen as the preferred specification. However, when lagged values of the NHPI were introduced, the coefficients on the income and housing stock variables no longer had the expected sign. As a result, these coefficients were eliminated from the equation and so the NHPI is not estimated using a stock-demand framework. The preferred estimation of equation (2.5) for the NHPI is presented below. The equation is estimated using ordinary least squares.

$$\begin{aligned}
&NHPI/CPI*100 \\
&= \underset{(4.34)}{7.2359} - \underset{(9.85)}{0.2198}*OC(-1) + \underset{(72.61)}{0.9501}*NHPI(-1)/CPI(-1)*100 \qquad (2.5a)
\end{aligned}$$

$\bar{R}^2 = .99$ Mean of Dep. Variable = 123.62
Durbin's h = 0.19 s = 1.9111
Period = 1972:4 to 1990:4

The estimated equation for the MLSP series is presented below.[9] The equation is estimated using ordinary least squares.

$$\begin{aligned}
&MLSP/CPI*100 \\
&= - \underset{(3.06)}{1448.6} + \underset{(1.53)}{1051.24}*YPD(-1)/HH(-1) - \underset{(-1.69)}{0.0543}*OC(-1) \\
&- \underset{(-3.05)}{220.69}*KHS(-1)/HH(-1) + \underset{(3.30)}{1555.03}*PPOP \\
&+ \underset{(8.01)}{0.7057}*MLSP(-1)/CPI(-1)*100 \qquad (2.5b)
\end{aligned}$$

$\bar{R}^2 = .93$ Mean of Dep. Variable = 101.70
Durbin's h = 0.70 s = 3.5134
Period = 1972:4 to 1990:4

The demand elasticities evaluated at the sample means are 0.30 for income and -0.77 for prices. These elasticities are consistent with typical findings for the U.S. housing market [Polinsky and

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[9]The MLSP is measured in thousands of dollars in order to make the results roughly comparable to the NHPI equation.

Ellwood (1979)].

2.4.2 Multifamily Housing Demand

The same stock-demand formulation used to model single family housing prices is used to estimate national rent levels as measured by the consumer price index for rented accommodations (CPIRA). Since the model specification alternatively determines the share of total households which demand single and multifamily housing, the same variables, including disposable income, the age-expected homeownership rate, the user cost of capital for homeownership, and the price of single family homes (as measured by the NHPI) are included in both specifications. Of course, the relevant housing stock in the equation estimating rent levels is the multifamily housing stock.

As with the results for the single family price equations, the age-expected homeownership rate was consistently of the wrong sign and so was excluded from the preferred specification. Other measures of demographic growth also failed to yield significant coefficients of the expected sign. The coefficients on the variables measuring the cost of single family housing, the NHPI, and the user cost of capital, were not significant. These results were also consistent with the single family price equations which did not find a significant correlation between the price of housing in these two markets.

The preferred specification for the rent equation is shown below. As with the single family price equations, the performance of the equation in simulations was greatly enhanced by the use of lagged dependent variables and so equation 2.8 is the preferred specification. Because of the strong positive correlations exhibited by the residuals, a maximum likelihood technique is used to correct for serial correlation.

$$\begin{aligned} CPIRA/CPI*100 = \underset{(3.10)}{20.11} - \underset{(-1.65)}{367.65}*YPD(-1)/HH(-1) \\ + \underset{(0.09)}{1.47}*KHM(-1)/HH(-1) + \underset{(32.55)}{0.9311}*CPIRA(-1)/CPI(-1) \end{aligned} \qquad (2.8a)$$

$\overline{R}^2 = .99$ Mean of Dep. Variable = 123.41
DW = 1.95 s = 0.7120
Rho = 0.5293 (6.06)
Period = 1963:2 to 1990:4

The negative income coefficient conforms to the expectation that rental housing is an inferior good and that the demand for rental

housing declines as household income increases. However, because of the highly insignificant stock coefficient, demand elasticities cannot be evaluated. As shown in equation (2.7) in Section 2.2.1, the coefficient on the housing stock variable is the inverse of the price coefficient from the stock demand model in equation (2.6). This coefficient is of great importance in the model because it is needed to recover the other coefficients of the stock demand model. Since the stock coefficient is insignificant the price elasticity cannot be calculated and the income coefficient cannot be recovered to calculate the income elasticity.

2.4.3 Single Family Housing Supply

As discussed in Section 2.2.2, the supply of new housing is determined by the expected profitability of housing construction given the relative costs of construction and the price of housing. The inputs used in new construction include labour, materials, land, and financing. Of these, only the coefficients on the cost of financing variables were significant and exhibited the appropriate negative signs. Ideally, this model should employ the real short-term interest rate used by builders or developers to finance housing construction. Of the interest rate series available, nominal five-year conventional mortgage rates (RMCB5YR) produced the most significant results and so this rate is used to proxy the construction financing rates in the estimations presented below.

In addition to the real price of new housing and financing rates, the preferred specification also includes dummy variables to control for seasonality in housing starts and a dummy variable for the Canadian Home Ownership Stimulation Program (DCHOSP) which provided $3,000 grants to first-time, new home buyers during the period 1982:1 to 1983:2. A dummy variable for the Registered Home Ownership Savings Plan (RHOSP) did not yield significant results.

Finally, since builders respond to demographic and economic trends which determine the demand for new housing units, the preferred specification as shown below also includes the absolute change in the population over age twenty-five (D25P) and the percentage change in employment for those age twenty-five and over (PEMP25). Once again, the residuals are highly positively correlated so a maximum likelihood technique is used to estimate the equation to correct for this problem.

$$
\begin{aligned}
HSS = & \underset{(2.26)}{-123557} - \underset{(16.42)}{13160*Q1} + \underset{(6.10)}{5566*Q2} + \underset{(5.98)}{4624*Q3} + \underset{(2.50)}{112.43*NHPI/CPI} \\
& - \underset{(7.40)}{2445*RMCB5YR(-1)} + \underset{(2.42)}{129330*PEMP25} + \underset{(3.96)}{0.1075*D25P} + \underset{(5.65)}{15190*DCHOSP}
\end{aligned}
\tag{2.9a}
$$

$\overline{R}^2 = .90$ Mean of Dep. Variable = 27324
DW = 1.88 s = 3164
Rho = 0.5503 (5.60)
Period = 1971:1 to 1990:2

The reported statistics are for the original data. The price elasticity of supply evaluated at sample means for this equation is 0.51.

2.4.4 Multifamily Housing Supply

Multifamily housing starts are estimated separately for apartments, semi-detached and row houses. Each of these types of multifamily housing supply is modelled in the same fashion as single family housing supply, with the return on investment being compared to the costs of production to determine the profitability of new supply.

For estimation purposes, the return on investment is measured by the rent level. The coefficient on this variable was significant for all multifamily structure types. The variables used to measure production costs include construction cost indexes and financing costs as proxied by real mortgage rates. Unfortunately, none of the variables used to measure production costs are significant in the equations. The rental cost of capital (RCAP), discussed in Section 2.2.2, is used to measure the cost of financing. This variable is of the expected sign and significant at the 90% confidence level in all three equations.

Dummy variables for various housing programs were attempted but none yielded plausible results. A dummy variable for the period during which the Assisted Rental Program (ARP) was in operation (1975:2 to 1978:4) measuring the effect of this subsidy program on multifamily housing starts did produce a significant coefficient for semi-detached and row housing, but not for apartment starts. Unfortunately, in each instance the magnitude of the coefficient was implausibly large. Rather than measure program effects, it is most likely that this variable was simply measuring unexplained swings in the proportion of starts in semi-detached and row housing, and in any event was also excluded from the model. Efforts to include the effects of rent control by means of dummy variables representing the time period and national coverage of rent control yielded consistently insignificant results and so are not included in the preferred specifications.

The national unemployment rate was included to measure swings in economic activity which might affect builders' perceptions of household formation and hence the demand for new housing. This variable was generally significant at the 90% confidence level.

Finally, attempts to include variables to explain changes in the

proportion of multifamily starts accounted for by the different structure types were unsuccessful. As a result, the equations may fail to accurately identify periods when a larger than average proportion of multifamily starts are accounted for by a given structure type - even though the total estimate of multifamily starts from the three equations may still be fairly accurate. In order to preserve the overall comparability, each structure type equation was estimated using a common variable list. As with the single family starts equation, a maximum likelihood technique was employed to correct for serial correlation. The preferred specifications are presented below.

$$\begin{aligned} HSSD = {} & \underset{(2.81)}{6259} - \underset{(4.73)}{28207} * RCAP(-1) + \underset{(0.46)}{6.0846} * CPIRA/CPI * 100 \\ & - \underset{(1.60)}{170.7} * UNEMP - \underset{(5.10)}{1015} * Q1 + \underset{(1.19)}{185} * Q2 - \underset{(0.08)}{10} * Q3 \end{aligned} \tag{2.10a}$$

$\bar{R}^2 = .81$ Mean of Dep. Variable = 2809
DW = 1.96 s = 557.7
Rho = 0.662 (7.71)
Period = 1971:1 to 1990:4

$$\begin{aligned} HSROW = {} & \underset{(2.63)}{12010} - \underset{(1.62)}{19355} * RCAP(-1) - \underset{(0.65)}{18.0} * CPIRA/CPI * 100 \\ & - \underset{(2.16)}{470.6} * UNEMP - \underset{(2.56)}{1023} * Q1 - \underset{(0.72)}{218} * Q2 - \underset{(1.24)}{316} * Q3 \end{aligned} \tag{2.10b}$$

$\bar{R}^2 = .64$ Mean of Dep. Variable = 4045
DW = 2.24 s = 1101
Rho = 0.685 (8.27)
Period = 1971:1 to 1990:4

$$\begin{aligned} HSAPT = {} & \underset{(1.34)}{15510} - \underset{(1.92)}{65509} * RCAP(-1) + \underset{(2.17)}{144.97} * CPIRA/CPI * 100 \\ & - \underset{(1.53)}{841.3} * UNEMP - \underset{(3.88)}{4587} * Q1 - \underset{(0.15)}{151} * Q2 - \underset{(1.49)}{1316} * Q3 \end{aligned} \tag{2.10c}$$

$\bar{R}^2 = .69$ Mean of Dep. Variable = 17579
DW = 1.86 s = 3561
Rho = 0.5278 (5.31)
Period = 1971:1 to 1990:4

The negative sign of the coefficient of the CPIRA/CPI variable, contrary to the _a priori_ expectation, may be due to the great deal of condominium/ownership that exists in row starts. The price elasticity of supply for apartment starts (HSAPT) evaluated at sample means is 0.94. This estimate falls well within the range of supply elasticities found in comparable housing market models in the U.S. However, since the coefficient on the rent variable is not significant for either semi-detached or row structures, the price elasticity for these types of units is not statistically valid.[10]

Combining the results of the above equations, total multifamily housing starts are given by the following identity:

$$HSM = HSAPT + HSSD + HSROW \tag{2.10d}$$

2.4.5 Housing Stock

The stock of single and multifamily housing is estimated by adjusting the previous quarter's housing stock by current period housing completions and an estimated quarterly net loss of stock. The net loss of stock is the sum of the loss of housing units due to demolition or conversion to other uses, offset by the number of units added to the stock due to conversion of structures from other uses to the relevant residential category. The net loss of single and multifamily housing units are based on comparison of actual completions and estimated changes in housing stock for the period from 1961 to 1990. The identities representing these relationships are given below.

$$KHS = KHS(-1) - SLOSS + HCS \tag{2.15a}$$

$$KHM = KHM(-1) - MLOSS + HCM \tag{2.16a}$$

where

SLOSS = net loss of single family stock in period t; and
MLOSS = net loss of multifamily stock in period t.

In turn, single and multifamily housing completions are estimated as a function of housing starts from current and previous quarters. Various lag structures were attempted with the best results provided by the equations presented below. In the case of single-family housing completions the intercept term as well as the seasonal dummy variables were statistically insignificant.

---

[10]The wrong sign on the rent variable in the row structures equation should not have a significant impact on forecasts given the relatively small magnitude of the coefficient and the lack of variation in this data series over the last decade.

Single Family Completions

$$HCS = \underset{(15.08)}{0.3260*HSS} + \underset{(19.65)}{0.4834*HSS(-1)} + \underset{(8.06)}{0.1742*HSS(-2)} \tag{2.13a}$$

$\bar{R}^2 = .88$ Mean of Dep. Variable = 24447
DW = 2.07 s = 2470
Period = 1963:1 to 1990:4

Multifamily Completions

$$\begin{aligned} HCSD = {} & \underset{(0.88)}{128.6} + \underset{(3.01)}{0.1794*HSSD} + \underset{(5.85)}{0.4026*HSSD(-1)} + \underset{(4.06)}{0.2767*HSSD(-2)} \\ & + \underset{(1.59)}{0.0946*HSSD(-3)} - \underset{(2.84)}{497.8*Q1} + \underset{(1.06)}{151.5*Q2} + \underset{(1.47)}{280.6*Q3} \end{aligned} \tag{2.14a}$$

$\bar{R}^2 = .86$ Mean of Dep. Variable = 2661
DW = 1.89 s = 382.6
Period = 1963:1 to 1990:4

$$\begin{aligned} HCROW = {} & \underset{(4.42)}{692.8} + \underset{(0.84)}{0.0375*HSROW(-1)} + \underset{(10.51)}{0.1929*HSROW(-2)} \\ & + \underset{(9.40)}{0.2679*HSROW(-3)} + \underset{(9.26)}{0.2625*HSROW(-4)} + \underset{(9.93)}{0.1767*HSROW(-5)} \\ & + \underset{(0.24)}{0.0106*HSROW(-6)} - \underset{(6.46)}{1021*Q1} - \underset{(4.83)}{794*Q2} - \underset{(2.09)}{365*Q3} \end{aligned} \tag{2.14b}$$

$\bar{R}^2 = .89$ Mean of Dep. Variable = 3327
DW = 1.92 s = 581.8
Period = 1963:1 to 1990:4

$$\begin{aligned} HCAPT = {} & \underset{(4.42)}{3478} + \underset{(5.32)}{0.1384*HSAPT(-1)} + \underset{(11.58)}{0.1483*HSAPT(-2)} \\ & + \underset{(22.13)}{0.1483*HSAPT(-3)} + \underset{(14.69)}{0.1384*HSAPT(-4)} + \underset{(9.94)}{0.1186*HSAPT(-5)} \\ & + \underset{(6.61)}{0.0889*HSAPT(-6)} - \underset{(8.14)}{4402*Q1} + \underset{(0.72)}{398*Q2} + \underset{(0.31)}{171*Q3} \end{aligned} \tag{2.14c}$$

$\bar{R}^2 = .84$ Mean of Dep. Variable = 17640
DW = 2.05 s = 2020
Period = 1963:1 to 1990:4

The apartment and row equations were estimated by the Almon technique using second-degree and third-degree Almon variables with far period restrictions in order to ensure that a realistic proportion of starts are estimated to be completed in each quarter. When these equations were estimated without the Almon technique, the value of the coefficients varied greatly from quarter to quarter and so did not represent a realistic pattern of housing completions. The quarterly dummy variables were added to the multifamily equations in order to account for the seasonal variation in the pattern of completions which tends to be eliminated when a lengthy lag structure is used. The quarterly dummy variables are not used in the single family equation because more favourable results were obtained when they were omitted.

Combining the results of the above equations, total multifamily housing completions are given by the following identity:

$$HCM = HCAPT + HCSD + HCROW \tag{2.14d}$$

2.4.6 Housing Resale Market

This section presents the preferred equation for estimating the volume of existing home sales (MLSS). As discussed in Section 2.2.3 above, the approach used to model existing home sales is based on the theory that changes in the factors determining housing demand produce a disequilibrium between the desired quantity of housing services and the quantity currently being consumed. This disequilibrium occurs because high transaction costs associated with moving from one home to another deters homeowners from moving every time there is a change in the factors determining their demand for housing. A move, and hence the sale of an existing home, occurs when the increase in household utility from adjusting housing consumption is large enough to offset the transaction costs associated with moving. A move may be precipitated either by changes in demand factors increasing the utility gained by moving or changes in transaction costs which lower the cost of moving.

Of the factors discussed in Section 2.2.3 as potential determinants of the level of housing demand, neither changes in rent levels nor household income resulted in statistically significant coefficients. The factors which did enter significantly were changes in real mortgage rate (DRRMCB5YR)[11] and changes in existing house prices (DMLSP/CPI), both of which measure changes in the cost of housing. Mortgage rates are also an important transaction cost

[11] The real mortgage rate is estimated by subtracting the annual inflation rate given by the CPI all items index. The annual inflation rate is given by the percent change in the CPI index for the current quarter from the CPI index for the same quarter in the previous year.

since moving entails the renegotiation of housing debt at existing mortgage rates. Thus, a change in the mortgage variable also represents a change in moving transaction costs. Since the sales of existing homes are arising from the interaction of buyers and sellers, the sign of the price variable is not unambiguous a priori. The number of single family housing completions, which was also intended to proxy transaction costs by measuring the difficulty of locating alternative housing, did not yield significant results.

As discussed in Section 2.2.3, the volume of home sales will be related to the number of households and so the national household population is included as an independent variable to scale the number of estimated home sales. The household variable also acts as a time trend since the volume of MLS home sales increased consistently over this period, most probably reflecting expansion in the national coverage of the Multiple Listing Service over time. Quarterly dummies were also included to control for seasonal variations in sales during the year.

Finally, the preferred model includes a dummy variable representing the Canada Mortgage Renewal Plan (DCMRP) which subsidized the mortgage payments of qualifying homeowners forced to renew their mortgage during periods of high mortgage rates (1981:3 to 1983:4). This program would be expected to lower home sales since households that would otherwise be forced to move by rising housing costs were allowed to stay in their homes. The magnitude of the estimated coefficient for this variable is fairly large, suggesting that almost 11,000 fewer home sales were realized during each quarter the program was operating. This result suggests that this variable may overstate the effect of this program and in fact be proxying the depth of the recession in 1982. Since inclusion of the variable improved the results and did not significantly affect the remaining variables it was included in the final specification.

The preferred equation is presented below. The high positive correlation of the residuals necessitated the use of a maximum likelihood estimation technique to correct for serial correlation.

$$\begin{aligned} MLSS = & - \underset{(6.66)}{71893} - \underset{(2.84)}{1966.0}*DRRMCB5YR + \underset{(2.00)}{394.9}*DMLSP/CPI \\ & - \underset{(2.83)}{10658}*DCMRP + \underset{(2.62)}{3973}*Q1 + \underset{(6.99)}{13084}*Q2 \\ & + \underset{(6.07)}{10022}*Q3 + \underset{(10.70)}{.0144}*HH \end{aligned} \tag{2.11a}$$

$\overline{R}^2 = .89$ Mean of Dep. Variable = 21230
DW = 1.90 s = 6135
Rho = 0.563 (5.48)
Period = 1972:3 to 1990:2

2.5 Simulation Results

This section presents forecasts for 1991 from the housing sector model given by the estimated equations presented in Section 2.4. Since this period was not included in estimation of the model's equations this exercise provides a test of the model's ability to forecast outside of the estimation period. Simulation results using the housing sector model for the entire period 1972:4 to 1991:4 are also presented. The results represent the dynamic simultaneous solution of the system of equations presented in Section 2.4 with the mortgage sector variables treated as exogenous. At a later date it will be possible to link the housing sector with the mortgage and residential investment sectors of the model. The 1991 forecast results are based on a dynamic simulation beginning in the fourth quarter of 1990, while the extended dynamic simulation begins in the fourth quarter of 1972.

2.5.1 Forecast of 1991 Housing Prices

Table 2.1 presents actual and estimated 1991 values for each of the three housing price series. Estimates for all of the series were somewhat high, with the MLSP/CPI estimates exhibiting the largest deviation from actual price levels. In part the failure of the model to accurately forecast as sharp a decline in real prices as actually occurred may be attributed to the fact that the CPI index exhibited a spike in the first quarter of 1991 as the new tax on goods and services was introduced nationally.

The NHPI/CPI estimates show the same continual decline during the year as the actual price series, but are consistently 4-5% higher than the actual values. For the year as a whole, the average annual NHPI declined by 11.8%, while the model predicted only an 8.0% decline.

The forecast for the MLSP/CPI series called for fairly stable prices hovering around a 125.4 average,[12] representing a 2.6% increase over 1990 average prices. However, the actual series fluctuated but generally declined during the year, registering a 3.7% drop from 1990 levels.

Finally, the forecast of the CPIRA/CPI series called for the cost of rented accommodations to decline slightly from 1990 levels but to remain very stable throughout the year. In actuality, the CPIRA/CPI series declined in the first quarter of 1991, and then remained stable until exhibiting a slight increase in the fourth quarter. Nonetheless, the estimates were quite close to the actual levels and on average were only 1.6% too high. The actual series registered a 2.0% drop from 1990 levels while the forecast called for a 0.4% drop.

---

[12]MLS prices are measured in thousands of 1986 dollars.

2.5.2 Forecast of 1991 Housing Starts

Table 2.2 presents the housing model's forecast of housing starts by type for 1991. Despite some seasonal variation in the accuracy of the forecast, the total forecast of single detached units (HSS) for 1991 was very accurate, with starts forecasts exceeding actual levels by only 1.1%. The largest seasonal errors occurred in the first quarter, when forecast starts were 23.3% below actual levels, and the fourth quarter, when forecast starts were 9.3% above actual levels. These errors offset each other so that the total annual forecast was very close to actual levels. Compared to 1990, actual single detached starts were down 15.4%, while the forecast called for starts to decline by 14.5%.

The 1991 forecast of apartment (HSAPT) and row (HSROW) starts deviated significantly from actual levels, with the total annual forecast of apartment starts exceeding actual starts by 23.1% and the forecast of row starts falling 25.9% short of actual starts. The forecast for semi-detached units (HSSD) was significantly low in the first and fourth quarters and significantly low in the second and third quarters with the result that the total annual forecast was very accurate, only 0.3% higher than actual levels. The errors in the apartment and row starts offset each other somewhat so that the forecast of total multifamily starts exceeded actual starts by only 8.3%. Overall, actual multifamily (HSM) starts declined by 12.2% from 1990 levels, while forecast multifamily starts fell only 4.9%.

The inability of the housing sector model to accurately forecast seasonal variations in the pattern of housing starts is not surprising given that seasonality is accounted for using simple quarterly dummy variables. The use of quarterly dummy variables to account for seasonal variation in these series over a twenty year period will not explain sharp random variations due to unusual weather patterns or labour strikes or allow for changes in seasonal fluctuations over time due to such factors as improvements in construction technology.

2.5.3 Forecast of 1991 Housing Stock and Completions

Table 2.3 presents the housing sector model's forecast of the stock of single detached (KHS denoted by STOCKS) and multifamily (KHM denoted by STOCKM) housing. The housing stock estimates are based on an assumed loss rate of the existing stock and estimates of housing completions. Since the actual loss rate for 1991 is not known, both the "actual" and estimated housing stock are based on the same assumed loss rates for single and multifamily housing. The differences between the actual and estimated stock levels for 1991 are due to differences between actual and estimated completions. Since completions are a small part of the stock it is not surprising that the difference between actual and estimated

stock figures is generally less than 0.1%.

Despite seasonal fluctuations in the accuracy of forecast completions, annual total forecasts of completions are generally fairly accurate. The forecast of single detached completions (HCS) was only 1.9% below the actual number of completions. The largest deviation from actual completions is for apartment units (HCAPT) where the 1991 total forecast exceeded actual levels by 6.7%. Forecast semi-detached completions (HCSD) were only 0.3% short of the actual annual total, while forecast row completions (HCROW) were 4.0% larger than actual. Because of the somewhat excessive forecasts of apartment and row completions, the total forecast of multifamily completions was 5.5% above actual completions.

2.5.4 Forecast of 1991 MLS Sales

Table 2.4 presents actual and forecast levels of Multiple Listing Service Sales (MLSS) of existing houses. Once again there is significant seasonal fluctuation in the accuracy of the forecasts, most notably in the second quarter, with forecast sales 17.7% less than actual sales, and in the fourth quarter, with forecast sales 18.2% greater than actual. The quarterly errors offset each other, however, so that the annual total forecast is almost identical to actual total sales.

2.5.5 Housing Sector Model Simulation for 72:4 to 91:4

Figures 2.3 through 2.18 present graphs of actual and estimated levels of all variables included in the housing sector model for the period 1972:4 to 1991:4 (Tables 2.5 through 2.9 present the data from these figures). This simulation provides a test of the model's ability to track actual levels over an extended period of time. This test is particularly important for the housing price variables since lagged values of these variables play an important role in the estimation of current period prices. Thus, it is possible that errors in the estimation of prices in earlier periods will be compounded over time. In addition, since the price variables are used to estimate housing starts and sales of existing units, errors in the estimation of housing prices will lead to errors in other parts of the housing sector model as well.

Figure 2.3 presents the simulation results for the NHPI/CPI variable. As shown, there are very few years during which the simulation accurately estimates the precise level of the NHPI/CPI. However, the simulation is fairly accurate at modelling the general trend in prices. The simulation accurately identifies the early 1970s as having the highest housing prices of the estimation period, followed by a flattening of prices in the late 1970s, a steep drop in prices to a low point in 1985, and finally a rise in prices in the late 1980s. However, the simulation does not

adequately forecast the steep rise in prices in 1989 nor the severe fall in 1990.

Figure 2.4 presents the simulation results for the MLSP/CPI series. As with the NHPI/CPI simulation results, the model does well at predicting the general trend in prices over the simulation period. The model is somewhat more successful in forecasting the level of the MLSP/CPI over time as the simulated trend is much closer to actual price levels for this series. The notable exceptions are in the early 1970s when estimated prices were about 10% higher than actual prices and in 1990 when actual prices declined and simulated prices increased.

As mentioned above, part of the reason why the model may have failed to accurately predict the fall in prices in 1991 may be due to the unexpected spike in the inflation rate in the first quarter of the year due to the introduction of the goods and services tax.

Figure 2.5 presents the simulation results for the CPIRA/CPI series. The actual values for this series exhibit very little fluctuations over time so the simulated trend of a consistent fall in this series until the early 1980s followed by essentially flat values over the last decade fits the data very well.

Figure 2.6 presents the simulated results for single detached housing starts. The simulation appears to fit the data very well, particularly in the period since 1981. The model is much less successful at simulating multifamily starts as seen in Figures 2.7 through 2.10. The model is particularly poor at modelling multifamily starts in the mid 1970s when there were sharp fluctuations in both the level of overall multifamily starts and in the proportion of starts that were accounted for by semi-detached and row structure types. The model is somewhat more successful at simulating multifamily starts in the 1980s when starts were more stable, particularly in the period since 1988.

These graphs clearly illustrate problems associated with the use of simple quarterly dummy variables to account for seasonal variation in these series over a twenty year period. For some construction types, it appears that seasonality has diminished over the twenty year time period. For example, seasonal fluctuations in the level of apartment and semi-detached units were greater in the 1970s than in recent years. Such a shift in the pattern of seasonality could be the result of changing construction techniques which allow large scale projects to move forward at any point in the year.

The errors in the starts estimations are clearly visible in the stock simulations shown in Figures 2.11 and 2.12. The excessively low level of single detached starts simulated in the mid 1970s is represented by a single detached stock estimate that is consistently below the actual level until somewhat high estimates in the late 1970s bring the simulated stock back into line with

actual levels. Since the early 1980s the accuracy of the starts equations is shown by the tight fit between actual and estimated stock. Likewise, the movement of the estimated multifamily stock line above and below the actual stock line illustrates how the starts simulation alternately over and underestimates actual starts with much tighter estimates being achieved at the end of the simulation period.

The simulation of housing completions are shown in Figures 2.13-2.17. Since completions closely follow starts, the errors evident in these simulations mirror the errors shown in the starts equations. Also evident in these figures, particularly the semi-detached and row completions, is the decline in seasonal fluctuations in completions over time.

Finally, Figure 2.18 presents the simulation of MLS sales of existing homes. In general the simulation fits the actual trend in MLS sales quite well. The periods of significant divergence occur in 1984 and 1990 when estimated sales exceeded actual sales and 1988 when estimated sales were below actual sales. Overall, the model performs reasonably well.

TABLE 2.1

Comparison of Housing Price Forecasts for 1991 with Actual Values

Variable	Mar–91	Jun–91	Sep–91	Dec–91	1991	1990
NHPI/CPI	107.5	106.4	106.1	105.9	106.5	120.8
Estimate	112.2	111.5	110.8	109.9	111.1	
Error (%)	4.4%	4.8%	4.5%	3.9%	4.4%	
MLSP/CPI	118.7	121.9	114.3	115.8	117.7	122.2
Estimate	124.7	125.7	125.7	125.5	125.4	
Error (%)	5.0%	3.0%	10.0%	8.3%	6.5%	
CPIRA/CPI	96.2	96.1	96.4	97.4	96.5	98.5
Estimate	98.2	98.1	98.0	98.1	98.1	
Error (%)	2.1%	2.1%	1.7%	0.7%	1.6%	

TABLE 2.2

Comparison of Housing Starts Forecasts for 1991 with Actual Values

Variable	Mar–91	Jun–91	Sep–91	Dec–91	1991	1990
HSS	8,572	27,551	28,380	22,064	86,567	102,315
Estimate	6,578	28,208	28,635	24,109	87,530	
Error (%)	–23.3%	2.4%	0.9%	9.3%	1.1%	
HSAPT	6,380	12,405	13,205	11,885	43,875	55,524
Estimate	8,137	15,358	14,843	15,661	53,999	
Error (%)	27.5%	23.8%	12.4%	31.8%	23.1%	
HSSD	930	2,333	2,563	3,209	9,035	7,551
Estimate	677	2,850	2,859	2,672	9,058	
Error (%)	–27.2%	22.2%	11.6%	–16.7%	0.3%	
HSROW	1,933	4,206	4,312	6,269	16,720	16,240
Estimate	1,512	3,419	3,642	3,812	12,385	
Error (%)	–21.8%	–18.7%	–15.5%	–39.2%	–25.9%	
HSM	9,243	18,944	20,080	21,363	69,630	79,315
Estimate	10,326	21,627	21,344	22,144	75,442	
Error (%)	11.7%	14.2%	6.3%	3.7%	8.3%	

TABLE 2.3

Comparison of Housing Stock Forecasts for 1991 with Actual Values

Variable	Mar-91	Jun-91	Sep-91	Dec-91	1991	1990
STOCKS	5,792,821	5,807,030	5,830,644	5,855,099	5,821,398	5,734,236
Estimate	5,788,920	5,804,350	5,827,888	5,853,921	5,818,770	
Error (%)	−0.1%	−0.0%	−0.0%	−0.0%	−0.0%	
STOCKM	4,255,068	4,276,234	4,296,661	4,313,526	4,285,372	4,201,388
Estimate	4,254,407	4,274,948	4,295,280	4,316,200	4,285,209	
Error (%)	−0.0%	−0.0%	−0.0%	0.1%	−0.0%	
HCS	17,670	15,939	25,343	26,185	85,137	117,990
Estimate	16,786	16,009	24,118	26,616	83,530	
Error (%)	−5.0%	0.4%	−4.8%	1.6%	−1.9%	
HCAPT	13,649	15,836	14,057	9,826	53,368	63,616
Estimate	11,712	15,495	14,801	14,961	56,969	
Error (%)	−14.2%	−2.2%	5.3%	52.3%	6.7%	
HCSD	1,280	1,601	2,487	2,561	7,929	8,517
Estimate	1,088	1,676	2,321	2,817	7,903	
Error (%)	−15.0%	4.7%	−6.7%	10.0%	−0.3%	
HCROW	3,343	3,111	3,266	3,860	13,580	16,040
Estimate	3,668	3,614	3,455	3,389	14,127	
Error (%)	9.7%	16.2%	5.8%	−12.2%	4.0%	
HCM	18,272	20,548	19,810	16,247	74,877	88,173
Estimate	16,469	20,785	20,578	21,167	78,999	
Error (%)	−9.9%	1.2%	3.9%	30.3%	5.5%	

TABLE 2.4

Comparison of MLS Housing Sales Forecast for 1991 with Actual Values

Variable	Mar-91	Jun-91	Sep-91	Dec-91	1991	1990
MLSS	72,562	98,382	71,763	58,131	300,838	249,860
Estimate	73,952	80,971	77,289	68,738	300,949	
Error (%)	1.9%	−17.7%	7.7%	18.2%	0.0%	

Figure 2.1

Comparison of NHPIR and MLSPR

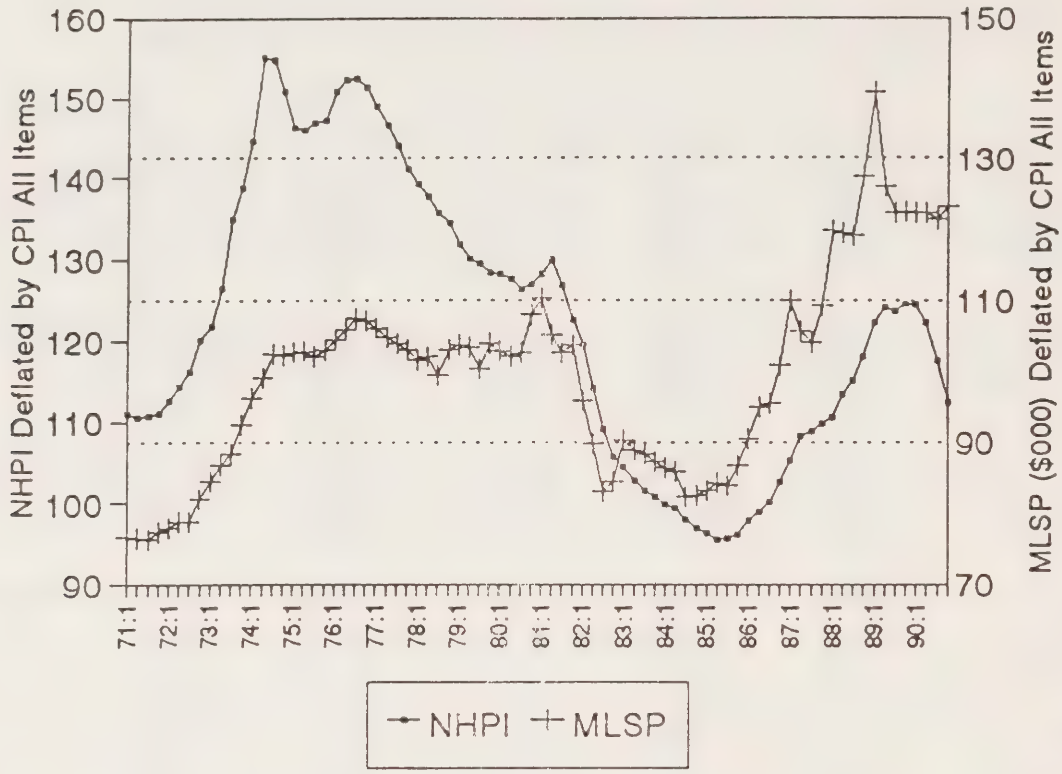


Figure 2.2

CPI Rental Cost Index and Multifamily Vacancy Rate

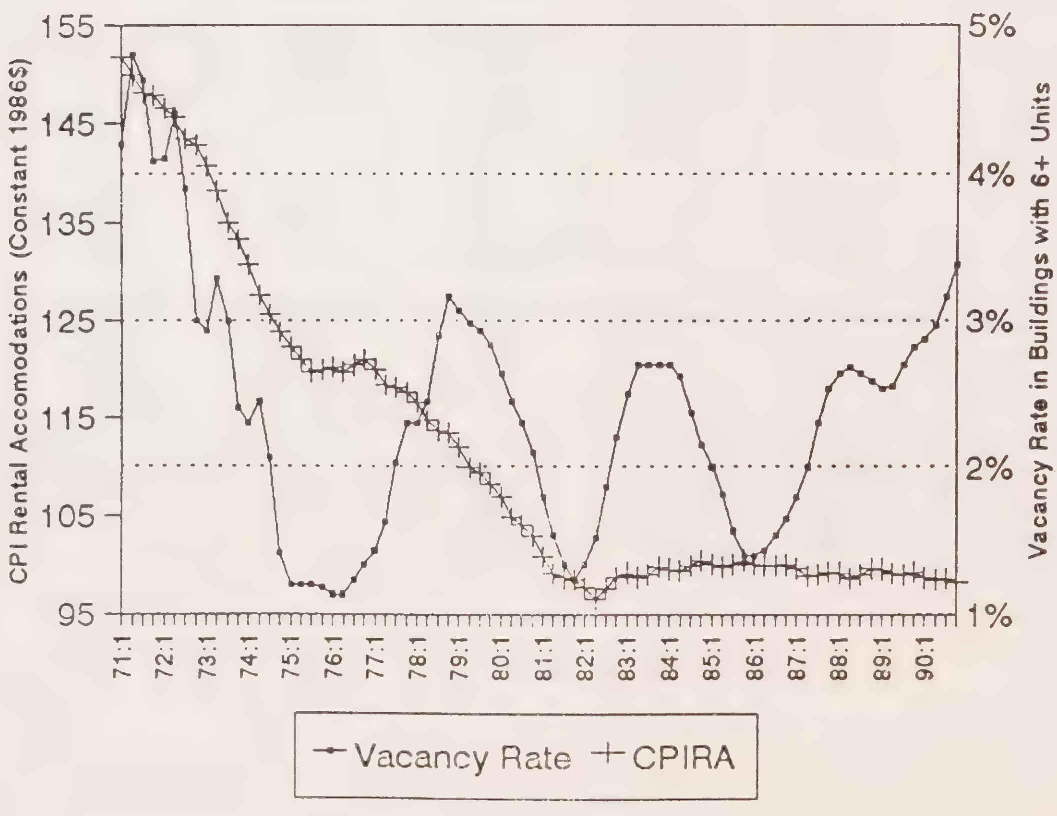


Figure 2.3

New House Price Index

Simulation Results for Equation 2.5a

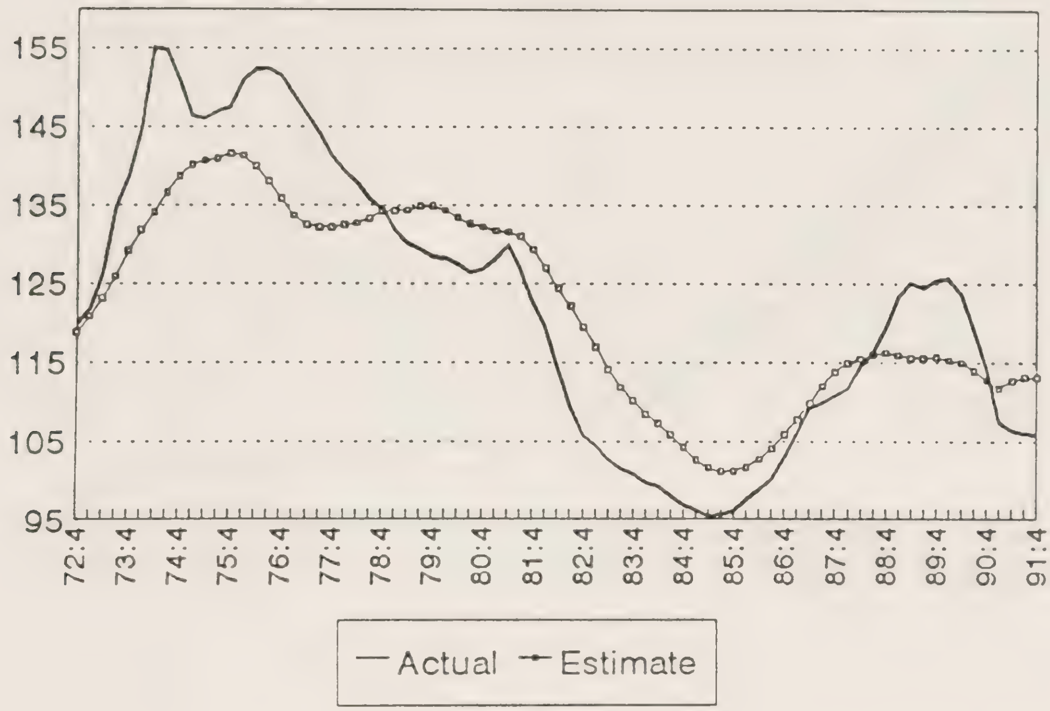


Figure 2.4

Multiple Listing Service Existing House Price

Simulation Results for Equation 2.5b

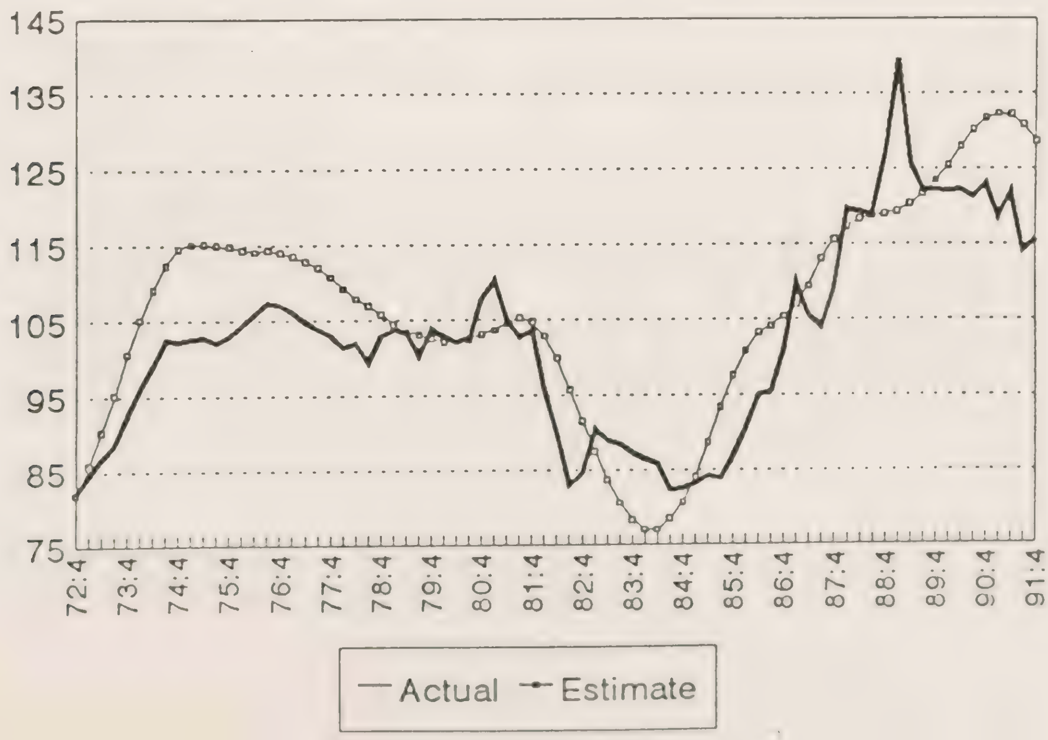


Figure 2.5

Consumer Price Index for Rented Accomodations

Simulation Results for Equation 2.8a

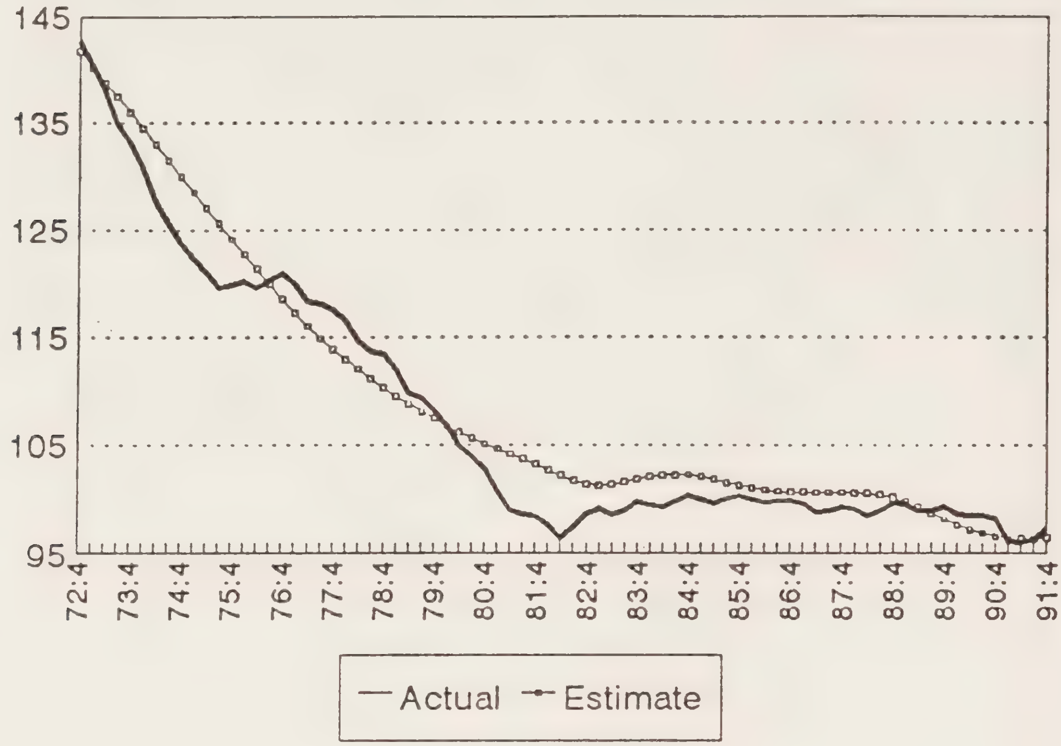


Figure 2.6

Starts of Single Detached Units

Simulation Results for Equation 2.9a

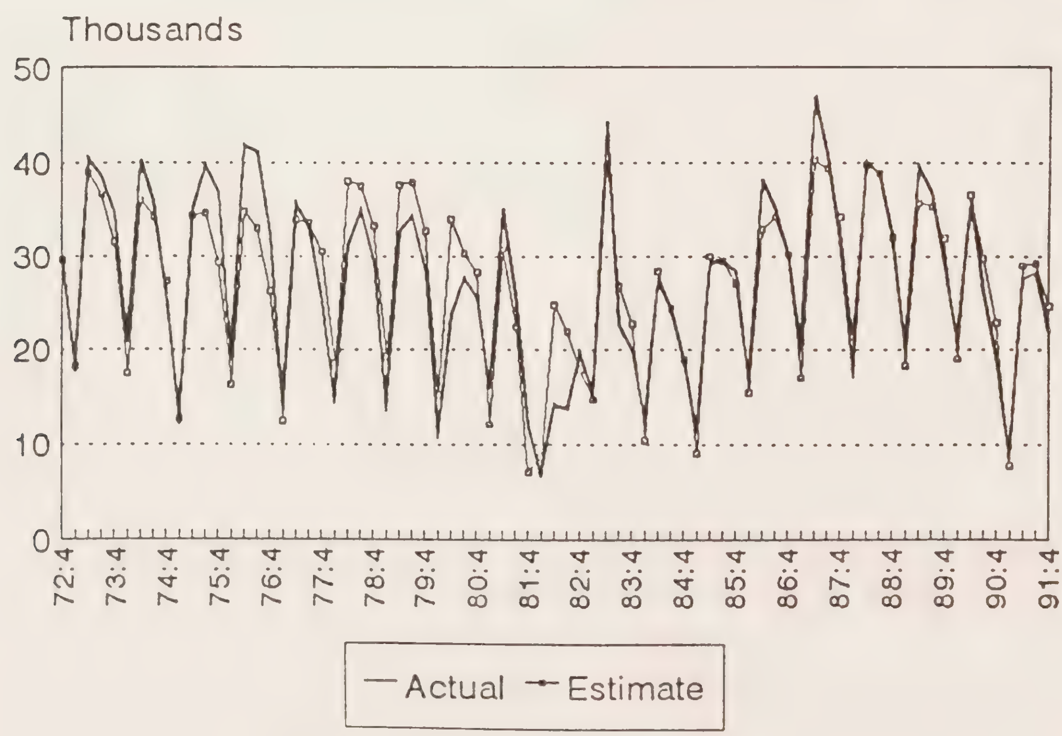


Figure 2.7

Starts of Apartment Units

Simulation Results for Equation 2.10a

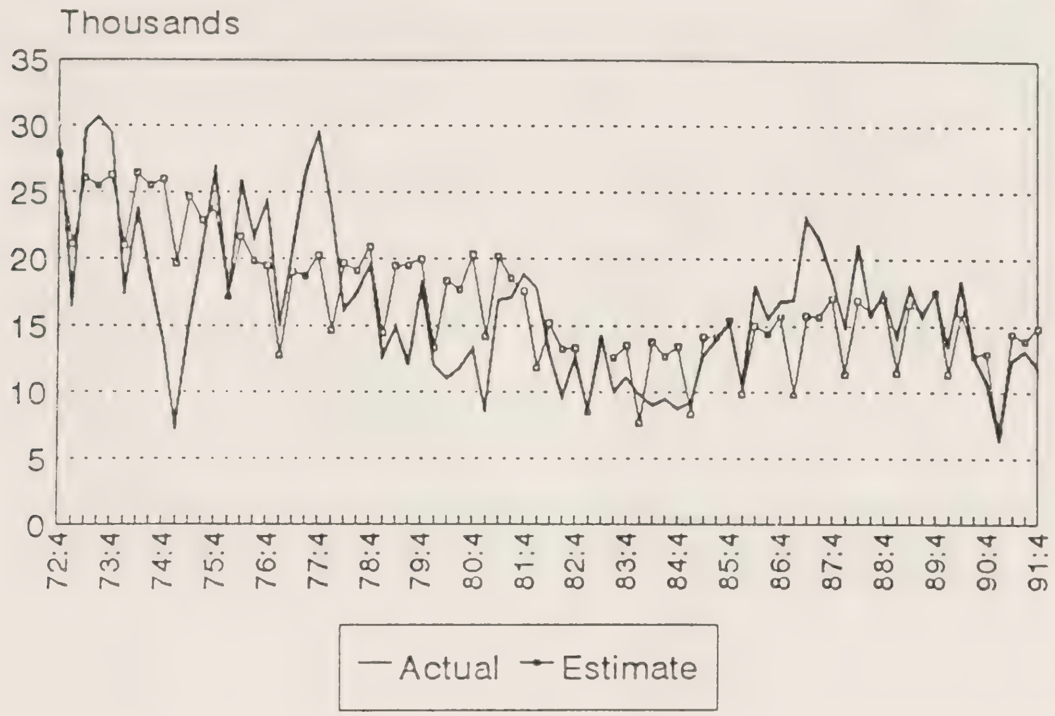


Figure 2.8

Starts of Semi-Detached Units

Simulation Results for Equation 2.10b

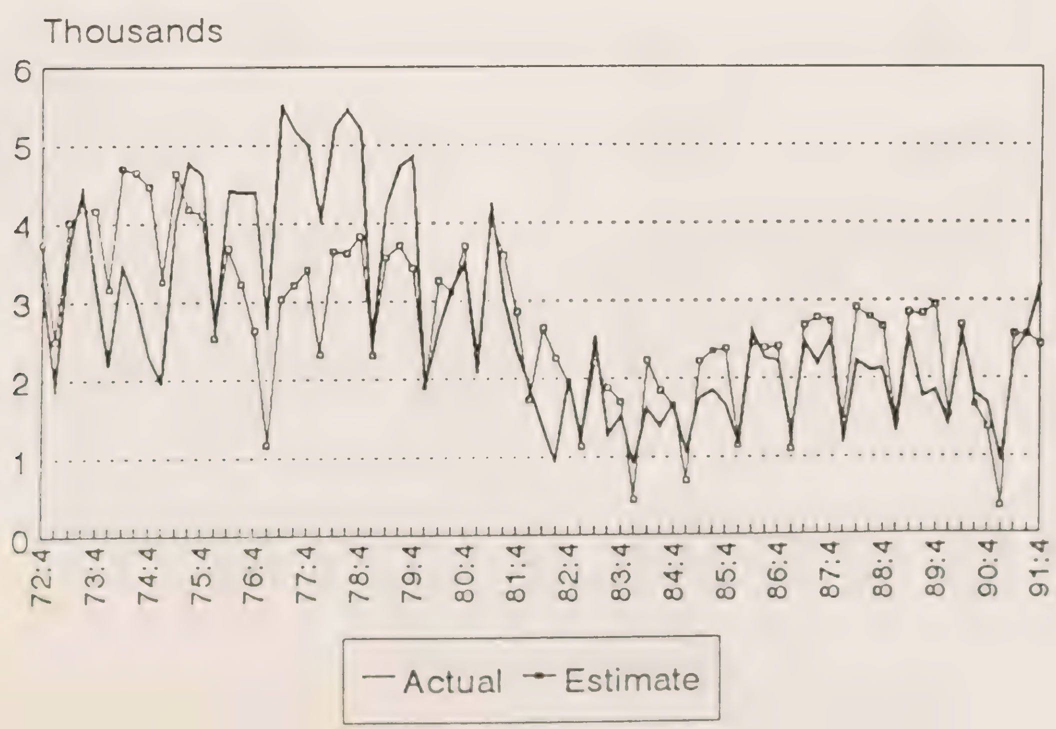


Figure 2.9

Starts of Row Units

Simulation Results for Equation 2.10c

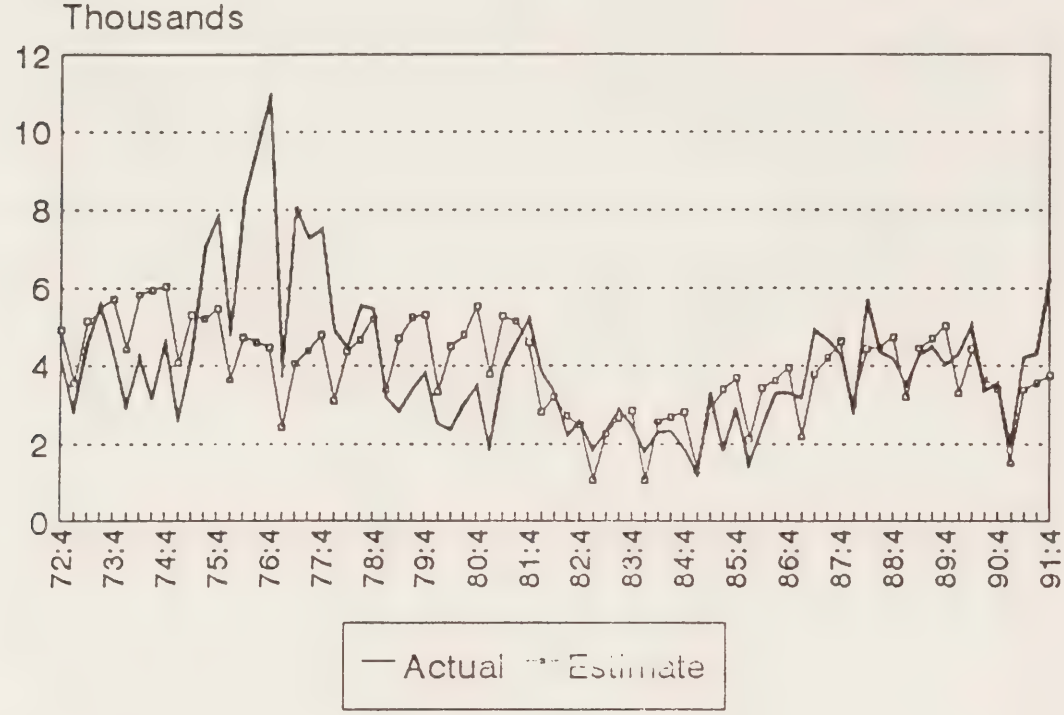


Figure 2.10

Starts of Multifamily Housing Units

Sum of Simulation Results for Equations 2.10 a-c

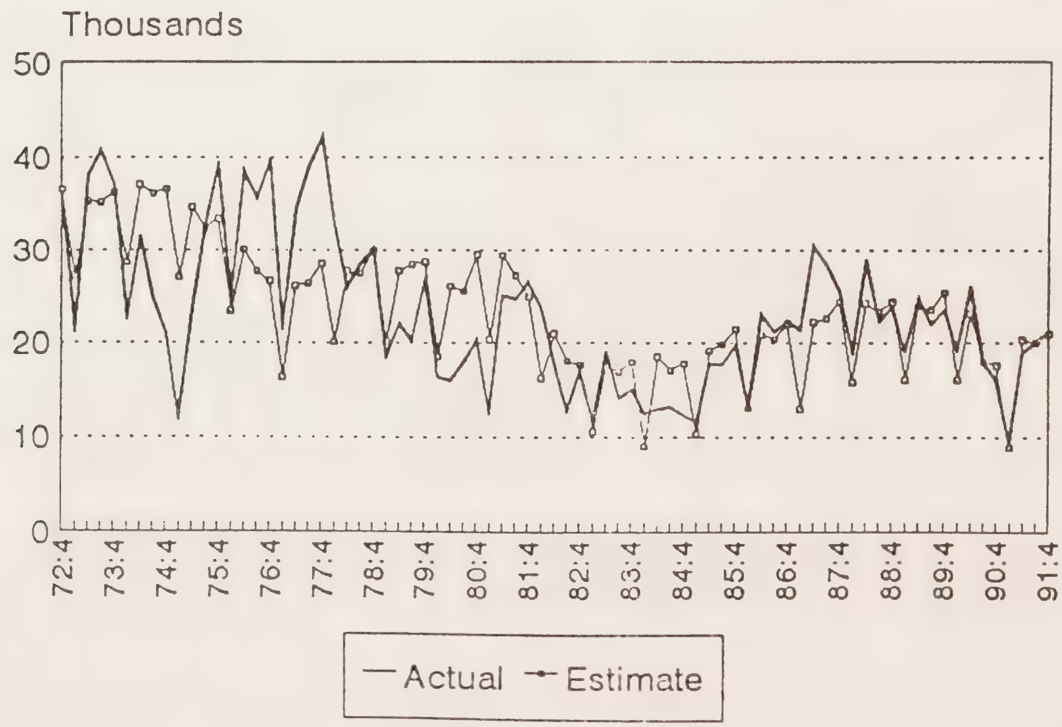


Figure 2.11

Single Detached Housing Stock

Simulation Results for Equation 2.15a

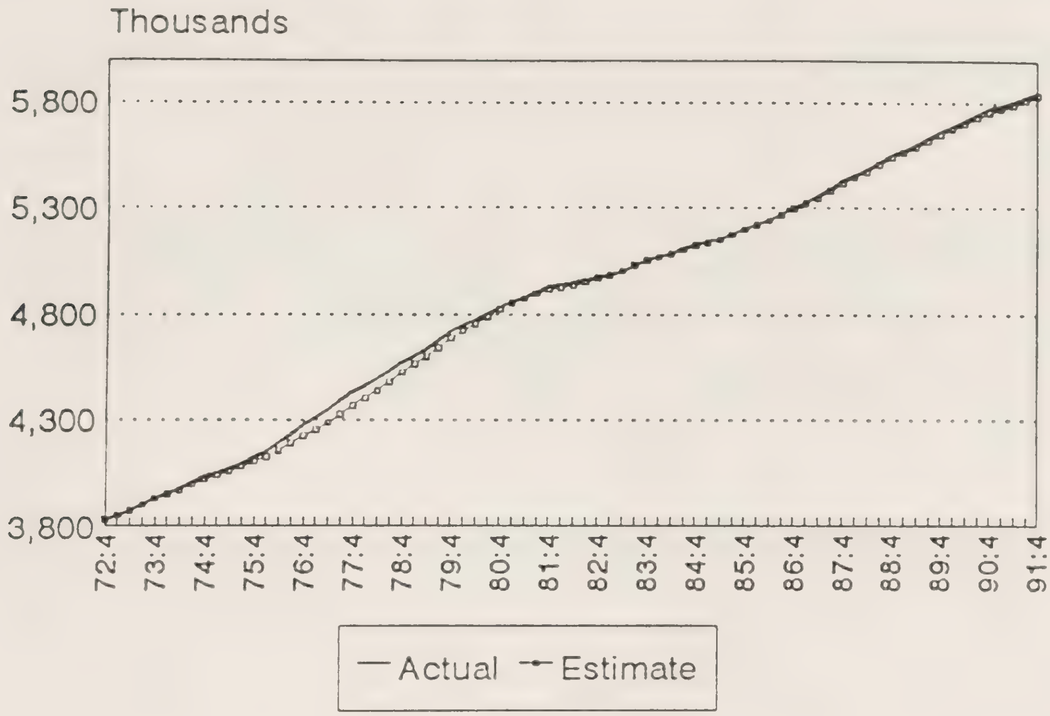


Figure 2.12

Multifamily Housing Stock

Simulation Results for Equation 2.16a

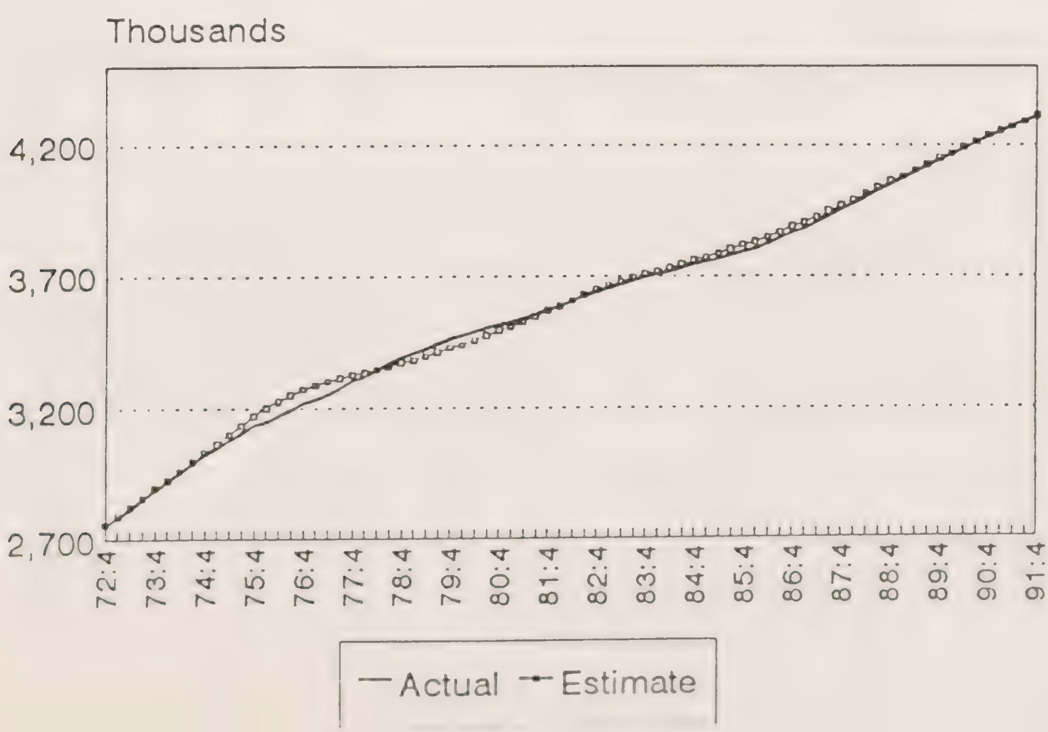


Figure 2.13

Completions of Single Detached Units

Simulation Results for Equation 2.13a

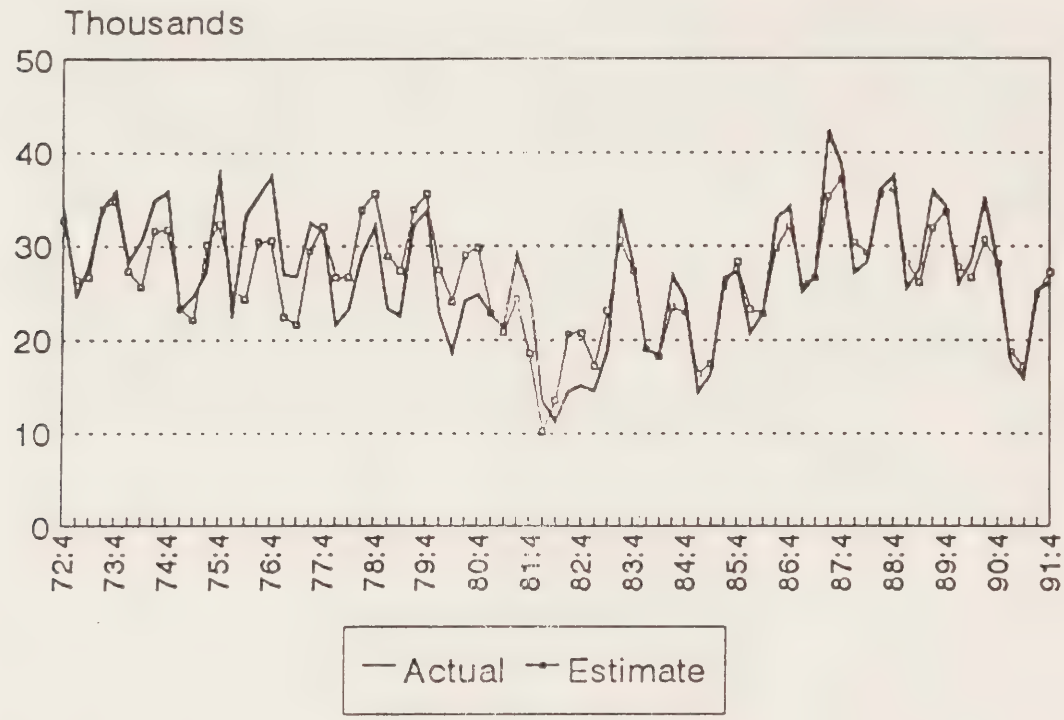


Figure 2.14

Completions of Apartment Units

Simulation Results for Equation 2.14a

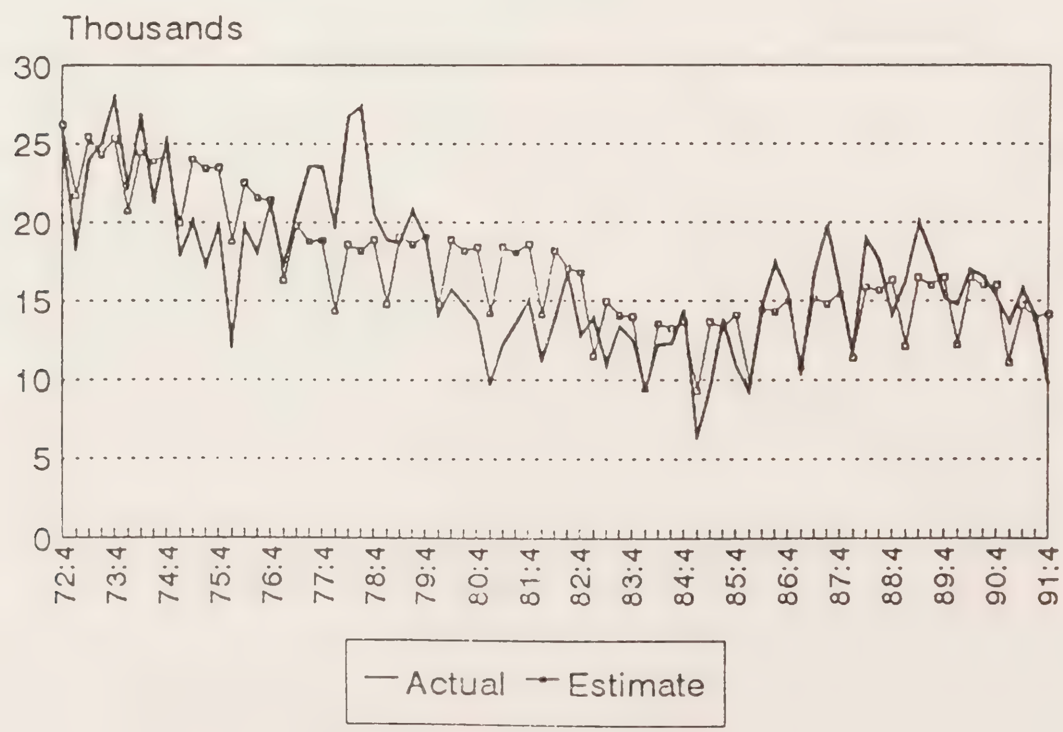


Figure 2.15

Completions of Semi-Detached Units

Simulation Results for Equation 2.14b

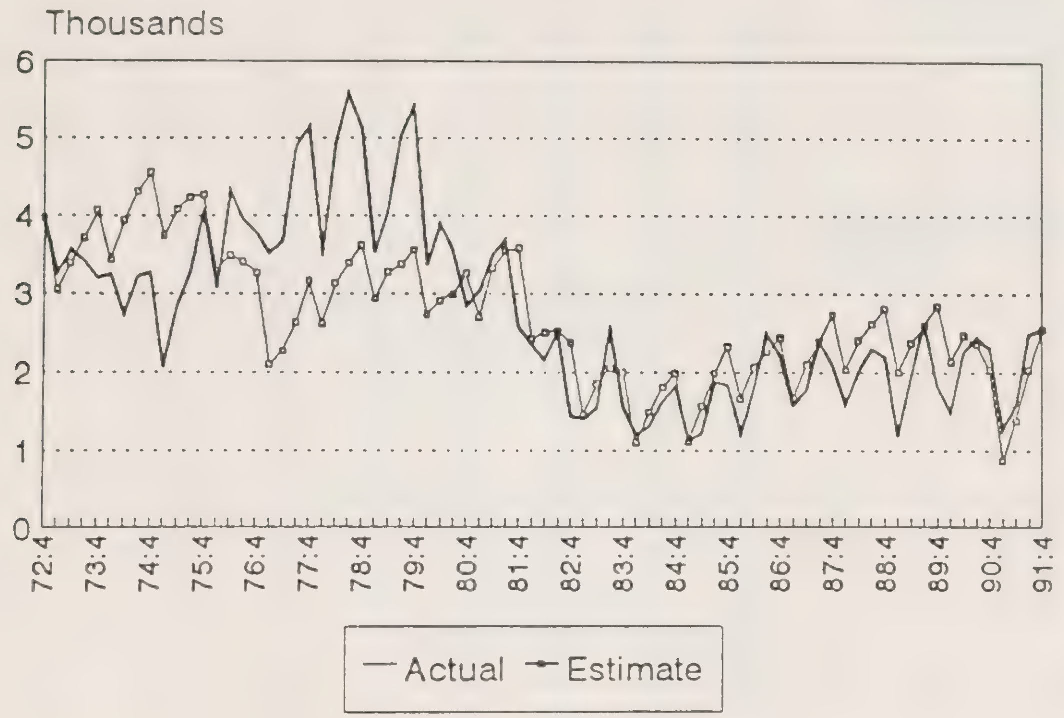


Figure 2.16

Completions of Row Units

Simulation Results for Equation 2.14c

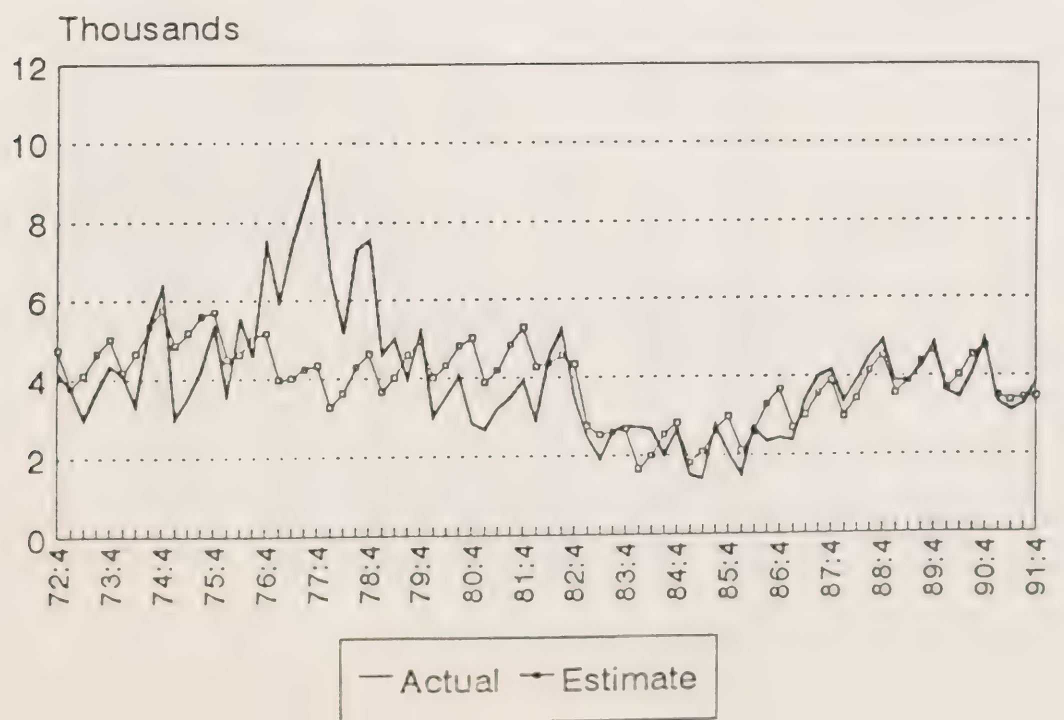


Figure 2.17

Completion of Multifamily Housing Units

Sum of Simulation Results for Equations 2.14 a-c

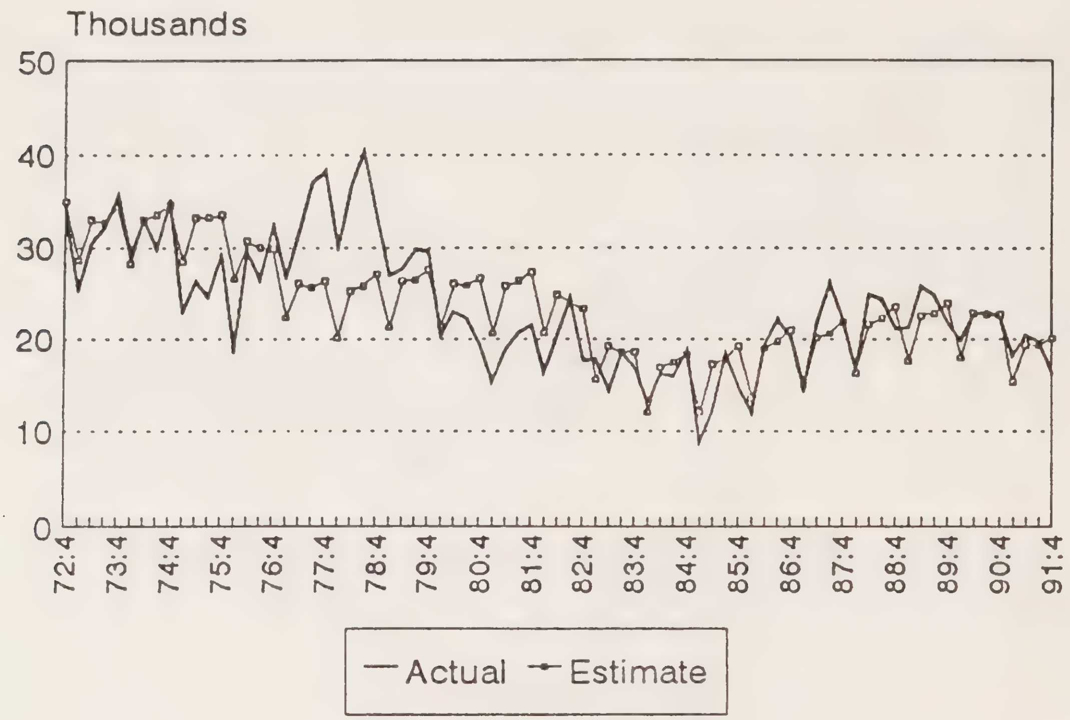


Figure 2.18

Multiple Listing Service Sales of Existing Houses

Simulation Results for Equation 2.11a

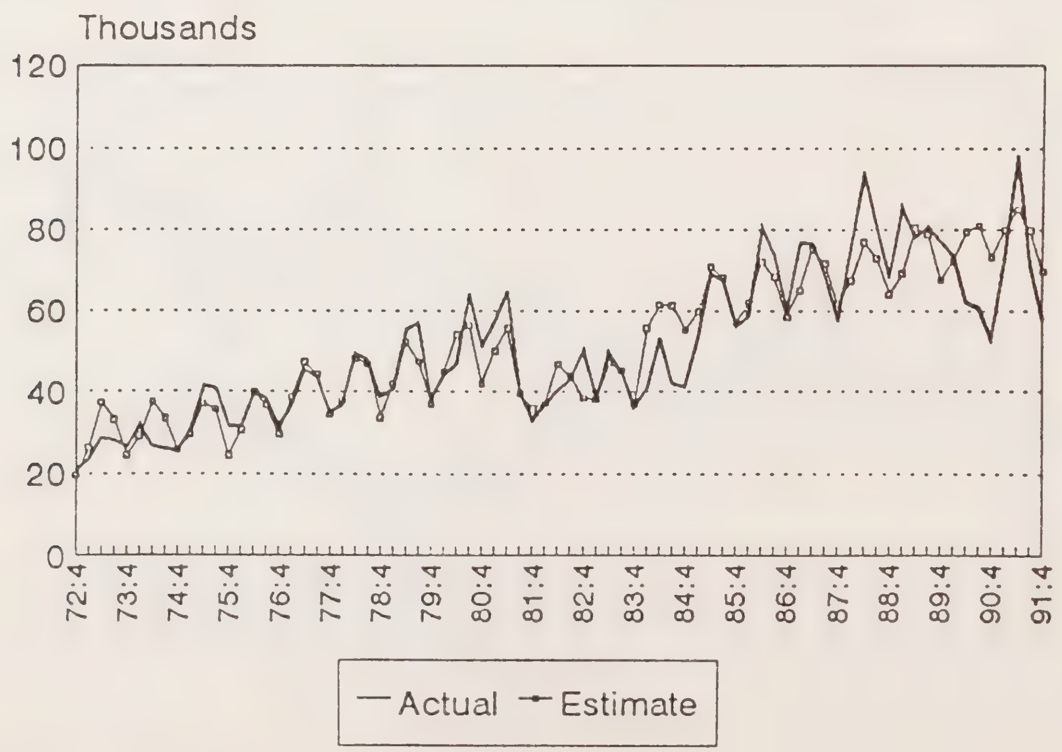


TABLE 2.5 – Housing Price Simulation Results

Date	NHPI/CPI Actual	NHPI/CPI Estimate	MLSP/CPI Actual	MLSP/CPI Estimate	CPIRA/CPI Actual	CPIRA/CPI Estimate
Dec-72	120.1	118.9	82.0	82.0	142.8	141.8
Mar-73	121.9	120.9	84.6	85.9	140.7	140.3
Jun-73	126.6	123.2	86.8	90.3	138.2	138.9
Sep-73	134.9	126.0	88.5	95.2	135.0	137.5
Dec-73	138.7	129.3	92.5	100.7	133.3	136.1
Mar-74	144.7	131.8	96.2	105.3	130.7	134.5
Jun-74	155.1	134.1	99.1	109.3	127.6	133.0
Sep-74	154.8	136.8	102.5	112.4	125.7	131.5
Dec-74	150.9	138.7	102.3	114.6	123.8	129.9
Mar-75	146.4	140.1	102.8	115.2	122.3	128.5
Jun-75	146.1	140.7	102.9	115.3	121.0	127.0
Sep-75	147.0	140.9	102.2	115.1	119.7	125.6
Dec-75	147.5	141.6	103.0	114.9	119.9	124.1
Mar-76	151.0	141.3	104.5	114.5	120.2	122.7
Jun-76	152.4	139.9	105.9	114.2	119.7	121.4
Sep-76	152.4	138.0	107.4	114.4	120.4	119.9
Dec-76	151.5	135.8	107.2	114.1	121.0	118.6
Mar-77	149.2	133.7	106.1	113.8	120.0	117.3
Jun-77	146.8	132.5	104.9	113.0	118.4	116.0
Sep-77	144.2	132.2	104.0	112.1	118.1	114.9
Dec-77	141.2	132.2	103.1	110.8	117.6	113.8
Mar-78	139.3	132.4	101.6	109.3	116.8	112.9
Jun-78	137.8	132.7	102.1	107.9	114.7	112.0
Sep-78	135.7	133.3	99.6	107.0	113.7	111.1
Dec-78	134.5	134.2	103.0	105.9	112.4	110.3
Mar-79	131.8	134.2	103.8	104.6	112.0	109.5
Jun-79	130.1	134.3	103.4	103.5	109.9	108.8
Sep-79	129.4	134.8	100.4	103.2	109.4	108.1
Dec-79	128.5	134.8	103.9	102.8	108.3	107.5
Mar-80	128.3	134.3	102.8	102.2	106.9	106.9
Jun-80	127.6	133.4	102.2	102.2	104.9	106.2
Sep-80	126.4	132.6	102.7	102.5	104.1	105.7
Dec-80	127.0	132.2	108.0	103.2	102.9	105.1
Mar-81	128.2	131.7	110.3	103.7	100.8	104.7
Jun-81	129.9	131.6	105.2	104.6	99.1	104.2
Sep-81	126.8	131.0	102.7	105.4	98.7	103.8
Dec-81	122.6	129.4	103.8	104.8	98.5	103.3
Mar-82	119.6	127.1	95.9	102.9	97.7	102.8
Jun-82	114.2	124.5	[illegible]	[illegible]	98.5	102.2
Sep-82	109.3	122.2	83.1	95.7	97.6	101.8
Dec-82	105.8	119.5	84.6	91.5	98.7	101.5
Mar-83	104.5	117.0	90.4	87.4	99.2	101.3
Jun-83	102.8	114.1	89.0	83.7	98.7	101.4
Sep-83	101.6	111.8	88.5	80.8	99.0	101.7
Dec-83	100.9	110.1	87.3	78.3	99.6	101.9
Mar-84	99.9	108.4	86.5	77.0	90.6	102.1
Jun-84	99.4	107.2	85.9	77.1	99.4	102.3
Sep-84	98.1	105.8	82.4	78.5	99.9	102.3
Dec-84	97.0	104.2	82.7	80.7	100.4	102.3
Mar-85	96.3	102.6	83.3	84.1	100.1	102.2
Jun-85	95.5	101.6	84.4	88.5	99.8	101.9
Sep-85	95.6	101.2	84.0	93.4	100.1	101.6
Dec-85	96.2	101.3	86.9	97.5	100.5	101.3
Mar-86	97.7	101.7	90.6	100.9	100.1	101.1
Jun-86	98.9	102.7	95.0	103.3	99.9	100.9
Sep-86	100.2	104.0	95.6	104.2	99.9	100.8
Dec-86	102.9	105.9	100.6	105.4	100.0	100.7
Mar-87	105.9	107.8	109.9	107.0	99.7	100.7
Jun-87	109.2	109.8	105.6	109.5	98.9	100.7
Sep-87	110.0	112.0	104.1	113.1	99.0	100.7
Dec-87	110.9	113.8	106.3	115.6	99.3	100.7
Mar-88	111.7	114.9	119.7	117.3	99.2	100.6
Jun-88	114.7	115.5	119.4	118.3	98.6	100.6
Sep-88	116.3	116.0	119.1	118.8	99.0	100.5
Dec-88	119.5	116.3	127.4	119.0	99.7	100.2
Mar-89	123.5	116.0	139.5	119.4	99.6	99.9
Jun-89	125.2	115.6	125.9	120.4	99.1	99.3
Sep-89	124.6	115.6	122.3	121.7	99.0	98.7
Dec-89	125.5	115.7	122.4	123.5	99.3	98.2
Mar-90	125.8	115.3	122.2	125.5	98.7	97.7
Jun-90	123.8	115.0	122.2	127.9	98.5	97.2
Sep-90	119.3	114.0	121.4	130.2	98.6	96.9
Dec-90	114.4	112.7	123.0	131.8	98.3	96.6
Mar-91	107.5	111.6	118.7	132.2	96.2	96.4
Jun-91	106.4	112.7	121.9	132.1	96.1	96.4
Sep-91	106.1	113.1	114.3	130.8	96.4	96.4
Dec-91	105.9	113.1	115.8	128.7	97.4	96.5

TABLE 2.8 – Housing Starts Simulation Results

Date	HSS Actual	HSS Estimate	HSAPT Actual	HSAPT Estimate	HSSD Actual	HSSD Estimate	HSROW Actual	HSROW Estimate	HSMF Actual	HSMF Estimate
Dec-72	30,177	29,813	28,883	27,928	3,268	3,741	4,177	4,923	36,128	36,592
Mar-73	17,734	18,276	16,415	21,113	1,854	2,501	2,795	3,557	21,064	27,171
Jun-73	40,504	39,000	29,769	26,148	3,693	4,032	4,567	5,131	38,029	35,311
Sep-73	36,819	36,583	30,693	25,516	4,462	4,207	5,583	5,456	40,738	35,178
Dec-73	34,605	31,530	29,574	26,326	3,226	4,174	4,348	5,735	37,148	36,235
Mar-74	20,801	17,456	17,379	21,044	2,187	3,165	2,900	4,413	22,466	28,821
Jun-74	40,286	36,018	23,898	26,483	3,487	4,714	4,228	5,837	31,813	37,034
Sep-74	35,976	34,271	18,714	25,533	3,028	4,653	3,130	5,950	24,881	36,144
Dec-74	25,080	27,328	14,034	26,043	2,321	4,478	4,665	6,054	21,020	36,575
Mar-75	12,230	12,813	7,204	19,726	1,957	3,273	2,559	4,062	11,720	27,061
Jun-75	35,180	34,344	15,345	24,726	4,024	4,639	4,235	5,310	23,604	34,675
Sep-75	39,762	34,666	20,785	22,947	4,793	4,191	7,055	5,199	32,633	32,336
Dec-75	36,757	29,387	27,027	23,847	4,829	4,121	7,914	5,456	39,570	33,425
Mar-76	18,873	16,345	17,230	17,218	2,663	2,548	4,759	3,635	24,652	23,400
Jun-76	41,926	34,768	25,902	21,711	4,418	3,690	8,294	4,725	38,614	30,125
Sep-76	41,285	32,966	21,623	19,911	4,403	3,237	9,608	4,599	35,634	27,746
Dec-76	32,229	26,281	24,569	19,564	4,406	2,639	11,015	4,468	30,990	26,672
Mar-77	14,213	12,520	15,035	12,808	2,853	1,167	3,705	2,419	21,393	16,395
Jun-77	35,739	33,904	21,018	19,082	5,528	3,043	8,084	4,057	34,630	26,182
Sep-77	33,190	33,562	26,587	18,819	5,185	3,225	7,300	4,384	30,072	26,427
Dec-77	25,261	30,511	29,687	20,324	5,007	3,413	7,532	4,775	42,226	28,512
Mar-78	14,343	18,618	23,920	14,686	4,017	2,328	4,917	3,112	32,854	20,128
Jun-78	31,174	38,008	16,229	18,710	5,245	3,647	4,455	4,360	25,929	27,718
Sep-78	35,006	37,478	17,571	19,147	5,465	3,615	5,552	4,684	28,588	27,426
Dec-78	29,506	33,301	19,607	20,932	5,205	3,835	5,455	5,213	30,267	29,980
Mar-79	13,587	19,239	12,769	14,482	2,467	2,311	3,201	3,399	18,437	20,192
Jun-79	32,781	37,627	15,065	19,489	4,224	3,558	2,840	4,688	22,129	27,735
Sep-79	34,339	37,905	12,159	19,507	4,733	3,709	3,376	5,219	20,268	28,435
Dec-79	28,410	32,745	18,394	19,988	4,872	3,421	3,832	5,298	27,006	28,707
Mar-80	10,672	15,267	12,048	13,374	1,872	1,900	2,520	3,330	16,440	18,604
Jun-80	23,734	33,982	11,085	18,339	2,621	3,244	2,385	4,472	16,091	26,055
Sep-80	27,776	30,341	11,863	17,661	3,153	3,104	3,008	4,765	18,024	25,530
Dec-80	25,539	28,242	13,333	20,282	3,503	3,687	3,489	5,522	20,325	29,491
Mar-81	15,964	12,181	8,535	14,195	2,084	2,326	1,833	3,765	12,452	20,287
Jun-81	35,113	30,800	16,979	20,157	4,259	4,025	3,925	5,265	25,183	29,446
Sep-81	26,029	22,534	17,170	18,483	3,029	3,563	4,553	5,122	24,752	27,168
Dec-81	11,965	7,162	18,925	17,557	2,306	2,829	5,214	4,585	26,535	24,970
Mar-82	6,697	8,782	17,866	11,770	1,918	1,709	3,847	2,795	23,631	16,275
Jun-82	14,272	24,815	12,929	15,185	1,417	2,620	3,347	3,190	17,603	20,904
Sep-82	13,792	21,931	9,719	13,170	927	2,232	2,219	2,698	12,865	18,100
Dec-82	19,696	17,897	12,848	13,302	1,992	1,928	2,574	2,475	17,214	17,705
Mar-83	15,373	14,742	8,524	8,475	1,259	1,104	1,852	1,056	11,635	10,634
Jun-83	44,442	39,771	14,381	13,246	2,546	2,183	2,317	2,260	19,224	17,688
Sep-83	22,643	26,857	10,058	12,519	1,283	1,857	2,890	2,632	14,231	17,008
Dec-83	19,927	22,795	11,181	13,461	1,527	1,679	2,462	2,836	15,170	17,976
Mar-84	12,488	10,539	9,853	7,608	913	433	1,816	1,050	12,582	9,091
Jun-84	27,527	28,424	9,114	13,802	1,623	2,208	2,307	2,565	13,044	16,575
Sep-84	24,432	24,421	9,556	12,636	1,384	1,827	2,324	2,679	13,264	17,143
Dec-84	19,204	19,030	8,819	13,406	1,672	1,633	1,868	2,796	12,359	17,835
Mar-85	11,471	9,169	9,352	8,316	1,082	683	1,214	1,315	11,648	10,315
Jun-85	29,222	29,989	12,815	14,117	1,742	2,206	3,324	2,866	17,881	19,189
Sep-85	29,545	29,476	14,069	14,154	1,853	2,336	1,830	3,386	17,752	19,877
Dec-85	28,386	27,098	15,340	15,435	1,661	2,369	2,920	3,676	19,921	21,460
Mar-86	16,243	15,531	10,393	9,846	1,166	1,132	1,470	2,141	13,029	13,119
Jun-86	36,221	32,845	18,052	15,031	2,620	2,449	2,309	3,432	23,071	20,912
Sep-86	35,169	34,219	15,635	14,389	2,260	2,372	3,310	3,629	21,205	20,391
Dec-86	30,375	30,236	16,940	15,713	2,226	2,389	3,306	3,951	22,472	22,053
Mar-87	20,304	17,048	16,971	9,770	1,269	1,002	3,175	2,182	21,415	13,044
Jun-87	47,013	40,257	23,138	15,751	2,474	2,664	4,924	3,784	30,536	22,199
Sep-87	40,937	39,330	21,569	15,675	2,191	2,773	4,648	4,201	28,408	22,650
Dec-87	31,885	34,225	18,692	17,038	2,526	2,726	4,270	4,619	25,488	24,384
Mar-88	17,039	21,447	14,887	11,364	1,173	1,443	2,774	3,048	18,834	15,855
Jun-88	40,171	39,768	21,126	16,886	2,227	2,896	5,690	4,429	29,043	24,211
Sep-88	38,738	38,778	15,868	16,009	2,106	2,780	4,357	4,481	22,331	23,269
Dec-88	32,519	32,088	17,607	17,008	2,122	2,661	4,160	4,725	23,889	24,394
Mar-89	19,809	18,307	14,239	11,465	1,323	1,468	3,493	3,199	19,055	16,130
Jun-89	39,523	35,727	17,958	16,815	2,582	2,833	4,258	4,449	24,798	23,897
Sep-89	36,933	35,316	15,754	16,058	1,776	2,823	4,406	4,691	22,026	23,572
Dec-89	29,613	31,926	17,677	17,448	1,843	2,934	4,015	5,018	23,535	25,400
Mar-90	20,689	19,054	13,398	11,334	1,432	1,532	4,292	3,293	19,122	16,158
Jun-90	36,231	36,470	18,463	18,039	2,626	2,682	5,026	4,427	26,115	23,148
Sep-90	26,188	29,612	12,745	12,764	1,810	1,655	3,362	3,658	17,917	18,076
Dec-90	19,209	22,887	10,918	12,897	1,683	1,376	3,560	3,406	16,161	17,678
Mar-91	8,572	7,804	6,380	7,170	930	353	1,933	1,510	9,243	9,033
Jun-91	27,551	29,039	12,405	14,417	2,333	2,582	4,206	3,388	18,944	20,364
Sep-91	28,380	29,284	13,205	13,888	2,563	2,566	4,312	3,566	20,060	20,021
Dec-91	22,064	24,677	11,885	14,863	3,209	2,440	6,269	3,749	21,383	21,052

TABLE 2.7 – Housing Stock Simulation Results

Date	STOCKS Actual	STOCKS Estimate	STOCKM Actual	STOCKM Estimate
Dec-72	3,836	3,834	2,758	2,760
Mar-73	3,854	3,855	2,786	2,791
Jun-73	3,876	3,876	2,819	2,826
Sep-73	3,904	3,904	2,853	2,861
Dec-73	3,934	3,932	2,891	2,896
Mar-74	3,958	3,953	2,923	2,928
Jun-74	3,980	3,972	2,958	2,964
Sep-74	4,009	3,998	2,991	3,000
Dec-74	4,038	4,023	3,028	3,037
Mar-75	4,056	4,040	3,054	3,068
Jun-75	4,075	4,058	3,082	3,104
Sep-75	4,098	4,080	3,110	3,140
Dec-75	4,129	4,107	3,142	3,178
Mar-76	4,158	4,127	3,153	3,205
Jun-76	4,195	4,158	3,176	3,229
Sep-76	4,236	4,192	3,196	3,252
Dec-76	4,278	4,228	3,222	3,275
Mar-77	4,315	4,258	3,238	3,290
Jun-77	4,352	4,287	3,255	3,303
Sep-77	4,395	4,327	3,280	3,316
Dec-77	4,436	4,369	3,305	3,329
Mar-78	4,466	4,406	3,322	3,336
Jun-78	4,497	4,441	3,345	3,347
Sep-78	4,535	4,483	3,372	3,360
Dec-78	4,575	4,527	3,392	3,373
Mar-79	4,607	4,564	3,409	3,381
Jun-79	4,639	4,600	3,425	3,397
Sep-79	4,680	4,643	3,444	3,412
Dec-79	4,723	4,687	3,463	3,429
Mar-80	4,752	4,724	3,476	3,430
Jun-80	4,777	4,754	3,491	3,458
Sep-80	4,807	4,790	3,506	3,476
Dec-80	4,839	4,826	3,517	3,494
Mar-81	4,861	4,855	3,526	3,507
Jun-81	4,881	4,875	3,542	3,528
Sep-81	4,910	4,899	3,558	3,550
Dec-81	4,934	4,917	3,575	3,572
Mar-82	4,945	4,926	3,588	3,588
Jun-82	4,953	4,937	3,606	3,610
Sep-82	4,965	4,955	3,628	3,631
Dec-82	4,978	4,973	3,642	3,652
Mar-83	4,989	4,987	3,657	3,664
Jun-83	5,004	5,007	3,669	3,681
Sep-83	5,034	5,034	3,685	3,696
Dec-83	5,058	5,057	3,699	3,712
Mar-84	5,074	5,073	3,709	3,721
Jun-84	5,089	5,088	3,722	3,735
Sep-84	5,112	5,106	3,735	3,749
Dec-84	5,134	5,127	3,751	3,765
Mar-85	5,145	5,140	3,758	3,774
Jun-85	5,158	5,155	3,768	3,789
Sep-85	5,182	5,177	3,784	3,805
Dec-85	5,206	5,203	3,797	3,822
Mar-86	5,225	5,223	3,809	3,834
Jun-86	5,245	5,243	3,828	3,853
Sep-86	5,276	5,271	3,849	3,872
Dec-86	5,307	5,300	3,869	3,892
Mar-87	5,331	5,324	3,884	3,907
Jun-87	5,356	5,349	3,908	3,928
Sep-87	5,398	5,382	3,935	3,950
Dec-87	5,433	5,417	3,959	3,974
Mar-88	5,458	5,445	3,977	3,991
Jun-88	5,484	5,473	4,003	4,014
Sep-88	5,518	5,506	4,028	4,037
Dec-88	5,554	5,540	4,051	4,062
Mar-89	5,577	5,566	4,072	4,081
Jun-89	5,602	5,590	4,099	4,104
Sep-89	5,636	5,620	4,124	4,127
Dec-89	5,668	5,651	4,146	4,152
Mar-90	5,691	5,676	4,166	4,170
Jun-90	5,718	5,701	4,190	4,194
Sep-90	5,751	5,729	4,213	4,217
Dec-90	5,777	5,755	4,236	4,240
Mar-91	5,793	5,772	4,255	4,258
Jun-91	5,807	5,788	4,276	4,275
Sep-91	5,831	5,813	4,297	4,294
Dec-91	5,855	5,830	4,314	4,314

TABLE 2.8 – Housing Completions Simulation Results

Date	HCS Actual	HCS Estimate	HCAPT Actual	HCAPT Estimate	HCSD Actual	HCSD Estimate	HCROW Actual	HCROW Estimate	HCMF Actual	HCMF Estimate
Dec-72	34,157	32,735	25,181	26,263	3,975	3,971	4,167	4,743	33,303	34,978
Mar-73	24,626	26,446	18,254	21,774	3,269	3,052	3,790	3,796	25,313	28,622
Jun-73	28,108	26,708	24,039	25,457	3,578	3,400	2,981	4,114	30,596	32,972
Sep-73	34,126	33,064	25,082	24,358	3,426	3,716	3,725	4,652	32,236	32,725
Dec-73	35,836	34,758	28,199	25,362	3,205	4,068	4,336	5,024	35,740	34,454
Mar-74	28,265	27,306	22,077	20,731	3,262	3,441	4,106	4,169	29,447	28,341
Jun-74	30,658	25,674	26,969	24,462	2,739	3,950	3,325	4,644	33,033	33,056
Sep-74	34,916	31,627	21,270	23,892	3,231	4,317	5,372	5,326	29,873	33,536
Dec-74	35,865	31,751	25,489	24,346	3,277	4,556	6,420	5,752	35,186	34,653
Mar-75	23,214	23,356	17,843	19,958	2,069	3,748	2,997	4,844	22,909	28,550
Jun-75	24,643	22,151	20,095	24,057	2,847	4,093	3,492	5,173	26,434	33,322
Sep-75	27,311	30,137	17,200	23,444	3,295	4,244	4,237	5,590	24,722	33,278
Dec-75	38,241	32,321	20,019	23,541	4,102	4,278	5,369	5,706	29,490	33,525
Mar-76	22,485	25,573	11,064	18,796	3,078	3,303	3,521	4,501	18,563	26,601
Jun-76	33,276	24,355	19,671	22,562	4,334	3,496	5,547	4,634	29,752	30,694
Sep-76	35,373	30,403	18,063	21,580	3,059	3,422	4,568	5,027	26,589	30,029
Dec-76	37,489	30,561	21,396	21,449	3,790	3,276	7,536	5,156	32,722	29,880
Mar-77	26,952	22,529	17,198	16,341	3,526	2,105	5,909	3,967	26,633	22,413
Jun-77	26,792	21,684	20,788	19,848	3,688	2,276	7,469	4,003	31,945	26,127
Sep-77	32,539	29,513	23,609	18,803	4,902	2,646	8,569	4,236	37,080	25,685
Dec-77	31,509	32,077	23,560	18,884	5,165	3,169	9,614	4,322	38,339	26,375
Mar-78	21,714	26,665	19,618	14,356	3,466	2,620	6,644	3,255	29,746	20,231
Jun-78	23,250	26,706	26,794	18,579	4,941	3,139	5,147	3,626	36,882	25,347
Sep-78	29,066	33,836	27,516	18,208	5,589	3,390	7,298	4,282	40,403	25,881
Dec-78	32,165	35,595	20,613	18,913	5,139	3,626	7,555	4,617	33,307	27,156
Mar-79	23,469	26,899	18,923	14,781	3,531	2,932	4,601	3,646	27,055	21,359
Jun-79	22,605	27,388	18,722	19,105	4,052	3,273	5,020	4,008	27,794	26,385
Sep-79	32,223	33,900	20,791	18,617	5,037	3,365	3,975	4,597	29,803	26,579
Dec-79	33,808	35,554	19,017	19,110	5,451	3,557	5,264	4,946	29,732	27,612
Mar-80	22,923	27,409	14,130	14,760	3,369	2,726	3,003	4,001	20,502	21,486
Jun-80	18,725	24,163	15,727	18,894	3,904	2,897	3,506	4,310	23,139	26,101
Sep-80	24,209	26,979	14,766	16,149	3,550	2,978	4,043	4,805	22,361	25,932
Dec-80	24,863	29,794	13,750	18,401	2,852	3,244	2,844	4,095	19,446	26,640
Mar-81	22,770	22,909	9,648	14,141	3,045	2,685	2,665	3,862	15,358	20,689
Jun-81	21,473	20,849	12,202	18,358	3,505	3,308	3,183	4,178	18,890	25,843
Sep-81	29,009	24,358	13,581	18,021	3,699	3,533	3,477	4,819	20,757	26,373
Dec-81	25,160	18,593	15,070	18,568	2,582	3,565	3,927	5,251	21,579	27,385
Mar-82	13,576	10,250	11,140	14,048	2,381	2,400	2,855	4,264	16,358	20,712
Jun-82	11,359	13,583	13,806	18,128	2,158	2,489	4,561	4,348	20,615	24,963
Sep-82	14,603	20,676	16,842	17,012	[illegible]	2,400	5,223	4,546	24,580	24,057
Dec-82	15,182	20,759	12,782	16,708	1,446	2,346	3,443	4,321	17,671	23,375
Mar-83	14,646	17,276	13,926	11,389	1,413	1,434	2,468	2,731	17,807	15,555
Jun-83	18,890	23,210	10,960	14,900	1,548	1,832	1,908	2,409	14,416	19,231
Sep-83	33,862	30,551	13,405	13,964	2,597	2,031	2,620	2,585	18,622	18,580
Dec-83	27,920	27,342	12,521	13,935	1,571	1,988	2,751	2,665	16,843	18,588
Mar-84	18,947	19,134	9,249	9,332	1,205	1,074	2,708	1,631	13,162	12,037
Jun-84	18,494	18,332	12,242	13,460	1,304	1,474	2,684	1,980	16,210	16,914
Sep-84	26,884	23,539	12,276	13,160	1,630	1,787	2,002	2,501	15,908	17,447
Dec-84	24,550	22,961	14,411	13,582	1,823	1,977	2,623	2,807	16,857	18,366
Mar-85	14,434	16,449	6,234	9,233	1,145	1,089	1,503	1,787	8,862	12,109
Jun-85	16,404	17,534	9,567	13,563	1,210	1,557	1,389	2,074	12,166	17,195
Sep-85	26,718	25,706	13,821	13,263	1,884	1,970	2,738	2,622	18,443	17,855
Dec-85	27,338	26,307	10,836	14,027	1,843	2,313	2,042	2,961	14,721	19,301
Mar-86	20,847	23,297	9,257	9,893	1,217	1,655	1,404	2,099	11,968	13,648
Jun-86	22,904	22,936	14,803	14,421	1,806	2,055	2,697	2,593	19,306	19,069
Sep-86	32,948	29,740	17,454	14,262	2,491	2,241	2,351	3,280	22,206	19,784
Dec-86	34,203	32,121	15,477	14,926	2,232	2,422	2,424	3,664	20,133	21,012
Mar-87	25,286	26,135	10,293	10,764	1,589	1,670	2,362	2,689	14,244	15,123
Jun-87	26,832	26,633	16,821	15,075	1,768	2,085	3,421	3,016	22,010	20,176
Sep-87	42,313	35,254	19,835	14,744	2,406	2,385	4,011	3,545	26,252	20,673
Dec-87	38,816	37,183	15,965	15,392	2,101	2,723	4,157	3,882	22,223	21,908
Mar-88	27,249	30,388	11,737	11,300	1,590	2,017	3,356	2,981	16,683	16,299
Jun-88	28,328	29,295	19,033	15,812	2,026	2,303	3,897	3,431	24,956	21,636
Sep-88	36,091	35,604	17,642	15,587	2,297	2,810	4,511	4,131	24,450	22,328
Dec-88	37,543	36,135	14,115	16,279	2,108	2,801	4,919	4,531	21,232	23,611
Mar-89	25,587	28,235	16,258	12,070	1,183	1,997	3,873	3,564	21,314	17,631
Jun-89	27,578	26,087	20,058	16,400	1,951	2,367	3,877	3,863	25,884	22,630
Sep-89	35,936	31,974	17,992	15,961	2,643	2,601	4,226	4,383	24,661	22,945
Dec-89	34,300	33,704	15,177	16,453	1,825	2,844	4,841	4,664	21,843	23,960
Mar-90	26,094	27,797	14,770	12,154	1,496	2,136	3,619	3,681	19,885	17,971
Jun-90	28,459	26,662	17,024	16,425	2,268	2,466	3,442	4,013	22,734	22,906
Sep-90	35,169	30,669	16,588	15,916	2,441	2,355	4,063	4,536	23,092	22,809
Dec-90	28,268	28,226	15,234	15,921	2,312	2,038	4,916	4,762	22,462	22,721
Mar-91	17,670	18,601	13,649	10,991	1,280	862	3,343	3,495	18,272	15,348
Jun-91	15,939	17,227	15,836	14,651	1,601	1,393	3,111	3,370	20,548	19,414
Sep-91	25,343	24,945	14,057	13,857	2,487	2,032	3,266	3,448	19,810	19,337
Dec-91	26,185	27,260	9,826	14,119	2,531	2,551	3,860	3,463	18,247	20,133

TABLE 2.9 – MLS Sales Simulation Results

Date	MLSS Actual	MLSS Estimate
Dec-72	21,079	18,657
Mar-73	23,470	25,463
Jun-73	28,802	36,709
Sep-73	28,145	32,828
Dec-73	26,706	24,878
Mar-74	32,066	28,989
Jun-74	26,966	37,415
Sep-74	26,190	33,531
Dec-74	25,941	26,836
Mar-75	30,980	30,299
Jun-75	41,600	37,356
Sep-75	40,827	36,140
Dec-75	31,756	25,173
Mar-76	31,773	30,896
Jun-76	40,212	40,013
Sep-76	38,291	36,356
Dec-76	31,764	30,033
Mar-77	36,793	38,839
Jun-77	45,734	46,966
Sep-77	43,542	43,845
Dec-77	35,041	34,436
Mar-78	36,830	37,111
Jun-78	49,737	47,319
Sep-78	48,050	45,974
Dec-78	39,052	33,201
Mar-79	41,029	41,318
Jun-79	55,302	51,433
Sep-79	57,211	46,369
Dec-79	38,569	36,726
Mar-80	44,226	44,263
Jun-80	47,057	53,028
Sep-80	64,342	56,030
Dec-80	51,656	41,587
Mar-81	57,248	40,576
Jun-81	64,771	54,178
Sep-81	39,718	39,080
Dec-81	33,238	36,978
Mar-82	37,204	37,640
Jun-82	40,606	47,336
Sep-82	43,500	44,506
Dec-82	50,638	40,369
Mar-83	38,470	38,774
Jun-83	50,087	47,515
Sep-83	45,338	45,661
Dec-83	36,377	38,225
Mar-84	41,073	55,506
Jun-84	53,437	60,347
Sep-84	42,179	60,307
Dec-84	41,354	55,386
Mar-85	53,473	58,957
Jun-85	69,409	69,817
Sep-85	67,489	67,245
Dec-85	56,270	56,786
Mar-86	56,682	60,908
Jun-86	60,859	71,170
Sep-86	73,719	67,384
Dec-86	59,951	57,773
Mar-87	77,051	63,506
Jun-87	76,850	73,415
Sep-87	68,348	69,664
Dec-87	57,536	60,383
Mar-88	75,838	65,958
Jun-88	94,217	75,474
Sep-88	81,000	71,703
Dec-88	68,250	63,600
Mar-89	85,727	68,354
Jun-89	78,169	79,250
Sep-89	80,898	77,853
Dec-89	77,445	66,788
Mar-90	73,661	70,961
Jun-90	82,321	77,137
Sep-90	80,836	79,322
Dec-90	53,043	72,503
Mar-91	72,562	79,130
Jun-91	98,382	83,815
Sep-91	71,763	78,457
Dec-91	58,131	68,008

3. Residential Investment

In this chapter we derive the basic equations explaining investment in residential construction. It is divided into two categories: new housing and other. Within the former category distinction is made among different types: single-family, semi-detached, row, and apartment as the cost of construction varies significantly over different types of housing. The latter category includes expenditures for conversions, alterations and improvements, cottages, mobile home sales, and supplementary acquisition costs.

3.1 Investment in New Housing

Statistics Canada constructs the quarterly figures on gross capital formation of residential construction from monthly figures. The monthly figures are in turn constructed by applying a set of variable weights of housing valuation, extending over a twenty-month period, to the number of dwellings started each month multiplied by the average cost per start for that month. This methodology is called the "work-put-in-place" approach.

Let HSM_{s-i} denote the housing starts in units in month s-i, and $c_{s,s-i}$ the proportion of work performed in month s on dwellings started in month s-i. Then the product $c_{s,s-i}\ HSM_{s-i}$ is the amount of work performed in month s on all dwellings started in month s-i. Since Statistics Canada assumes twenty months to be the maximum time taken to build a dwelling unit, the sum

$$PU_s = \sum_{i=0}^{19} c_{s,s-i}\ HSM_{s-i}, \tag{3.1}$$

is the total work put in place in month s on all dwellings started in current and past months, and is referred to as the number of "physical units" in month s. A physical unit is thus defined as the equivalent quantity of physical work necessary for building one average dwelling unit.

Since the construction process is time-consuming, the construction activity on a dwelling unit is certainly carried over from one month to the next. However, neither the duration nor the monthly distribution of work carried out is fixed. They are affected by the size and nature of the project as well as by the weather and other conditions.

Investment in residential construction is the value of the physical units in Eq.(3.1). In order to determine the value of the work put

in place in a given month, a cost factor must be applied to Eq. (3.1). Investment in new residential construction in month s is then

$$IHM_s = \sum_{i=0}^{19} c_{s,s-i}\, AC_{s-i}\, HSM_{s-i} = \sum_{i=0}^{19} a_i\, HSM_{s-i} \tag{3.2}$$

where AC_s is the average cost of dwellings started in month s and $a_i = c_{s,s-i}\, AC_{s-i}$. Thus a_0 is the average expenditure per dwelling unit in month s for units started in month s, a_1 is the average expenditure per unit in the month s for units started in month s-1, and so forth. However, the coefficients a_0, a_1, ..., a_{19} are not necessarily constant over time. They will vary as the work proportion $c_{s,s-i}$ varies and the average cost of a dwelling unit varies. Note that the average cost includes the material cost, the cost of labour and the contractor's profits, but not the land cost. Furthermore, as the household income grows, the quality and thus the value of a dwelling unit that households demand certainly improves and the average cost of a dwelling unit tends to increase over time.

Since the variable to be modelled is the quarterly residential investment, we aggregate monthly residential investment equation (3.2) over three months:

$$\begin{aligned} IHM_s + IHM_{s-1} + IHM_{s-2} &= a_0\, HSM_s + (a_0 + a_1)\, HSM_{s-1} \\ &+ (a_0 + a_1 + a_2)\, HSM_{s-2} + \dots + (a_{17} + a_{18} + a_{19})\, HSM_{s-19} \\ &+ (a_{18} + a_{19})\, HSM_{s-20} + a_{19}\, HSM_{s-21} \end{aligned} \tag{3.3}$$

Thus quarterly housing investment is a function of housing starts in the three months of the current quarter and the starts in the 19 months of the previous quarters.

From Eq. (3.3) we may write residential investment in new housing in quarter t, IHN_t, as a function of housing starts in the current and past seven quarters:

$$IHN_t = f(HS_t, HS_{t-1}, \dots, HS_{t-7}) \tag{3.4}$$

The HS_t variable in Eq. (3.4) are not in value terms. One possible way of handling the varying cost per housing is to divide IHN_t by a deflator of new residential construction ($PNRC_t$).

We define the dependent variable by $IHN_t/PNRC_t$, linearize the equation, and write

$$IHN_t/PNRC_t = c_0 + b_0\, HS_t + b_1\, HS_{t-1} + \dots + b_7\, HS_{t-7} \tag{3.5}$$

There is no guarantee that the coefficients in Eq. (3.5) are stable over time. In model estimation new housing investment as well as housing starts are to be disaggregated by type: single-detached, semi-detached, row and apartment. Such disaggregation should make coefficients in individual equations more stable and forecasts based on the model more accurate.

3.2 Other Residential Investment

Other components of residential investment include the value of conversions, alterations and improvements, cottages, and mobile homes. Conversions are dwellings created by altering existing structures. Alterations and improvements include structural changes made to existing dwellings like additions and alterations which do not result in the creation of additional dwellings. Note that the cottages are supposed to have been included in the alterations and improvements series until 1971, but the published CANSIM data on the cottages go as far back as 1961. Residential investment in mobile homes is the total value of the mobile homes installed during a given period.

The expenditures on conversions, improvements, cottages, and mobile homes are to be modelled in a framework similar to that for consumption expenditures. The equations for these investment expenditures relate them (in constant dollars) to permanent income, relative price, and the rate of interest:

$$IHO_t/CPI_t = f(YPD_t,\ PR_t,\ R_t)$$

or

$$IHO_t/CPI_t = c_0 + b_0\ YPD_t + b_1\ PR_t + b_2\ R_t \tag{3.6}$$

where IHO_t is the residential investment in other than new housing, YPD_t real personal disposable income, PR_t relative price, and R_t rate of interest, all in quarter t. Higher permanent income would lead to more expenditures while higher interest rates reduce expenditures. Thus equations of the form in (3.6) are used for expenditures in four categories, respectively: conversions, improvements, cottages, and mobile homes.

One other component in residential investment is supplementary acquisition costs. They include the costs incurred by the owner when acquiring a new property and are generally paid for on completion of dwellings and include legal, architect's and surveyor's fees. Their quarterly value depends on the number and types of dwellings completed during the quarter. The equation for this component relates the acquisition costs to the number of housing completions in the current and past quarters:

$$IHACQ_t/CPI_t = c_0 + b_0\ HCS_t + b_1\ HCS_{t-1} + b_2\ HCM_t + b_3\ HCM_{t-1}, \quad (3.7)$$

where $IHACQ_t$ is the residential investment in supplementary acquisition costs, HCS_t completions of single-detached housing, and HCM_t completions of multiple housing, all in quarter t.

3.3 Estimation Results of New Residential Investment Equations

In this section we present the estimation results of new residential investment equations discussed in Section 3.1. Results for other residential investment are reported in Section 3.4. For all residential investment equations a few "ground rules" were set as follows:

1) All variables in residential investment equations should be measured in constant dollars;
2) New residential investment is deflated by a deflator of new residential construction; and
3) Other residential investment as well as personal disposable income are deflated by the all-items consumer price index (CPI).

The spurious positive correlation arising from inflation would be eliminated by measuring all variables in dollar values at constant prices. The PNRC variable used in deflating new residential investment is defined as

$$PNRC = 100 \times (NRCGC + NRCBC) / (NRCGK + NRCBK)$$

where NRCGC: the government new residential construction in millions of current dollars;
NRCBC: the business new residential construction in millions of current dollars;
NRCGK: the government new residential construction at 1986 prices in millions of dollars; and
NRCBK: the business new residential construction at 1986 prices in millions of dollars.

Other residential investment is treated like consumption expenditures, and the CPI seems to be an appropriate deflator.

A note on the data: residential investment data modelled in this section comprise private and public expenditures on dwellings but exclude real estate commissions. Consequently, the figures in the data are not strictly comparable to those published in the National Accounts.

Equation (3.5) suggests that residential investment equations are to be modelled as a distributed lag of current and past starts for each type of housing. Although the equation itself was specified with a lag up to seven quarters for all types of new housing,

inclusion of all 7 lagged starts in estimation is not necessarily desirable in building a model for forecasting purposes, and we relied on empirical evidence to determine the appropriate lag length. Further, the aggregated personal disposable income (YPD) in the current and three preceding quarters deflated by the corresponding all-items consumer price index (CPI) is included as an additional regressor to reflect the increase in the average cost of a dwelling unit arising from households' demand for better quality of housing due to increasing income over time.

$$YPD = 100 *(PDI/CPI + PDI(-1)/CPI(-1) + PDI(-2)/CPI(-2) + PDI(-3)/CPI(-3))$$

where
PDI = personal disposable income in millions of dollars, and
CPI = all-items consumer price index (1986 = 100)

Although data series extend as far back as 1961 for estimating most of the investment equations, it was decided to limit the sample period from 1970:1 to 1990:4 (T = 84) since the technological change in housing construction was significant in the 1970s.

(1) New investment in single-detached housing

Least squares estimation of the investment equation for new single-detached housing gave the following results:

$$\begin{aligned} IHS/PNRC*100 = &- \underset{(-9.36)}{1647280} - \underset{(0.23)}{19557.2}*Q1 + \underset{(2.03)}{295169}*Q2 + \underset{(1.73)}{229701}*Q3 \\ &+ \underset{(4.85)}{26.538}*HSS + \underset{(4.62)}{31.957}*HSS(-1) + \underset{(0.62)}{3.414}*HSS(-2) \\ &+ \underset{(14.12)}{6.1029}*YPD \end{aligned} \qquad (3.8a)$$

$\bar{R}^2$ = .888   s = 224059
DW = .477   RHO = .801 (11.5)
Mean of IHS/PNRC = 1902670

where
IHS = new residential investment in single-detached housing, in thousands of current dollars;
PNRC = the implicit deflator of investment in new residential construction, 1986 = 100;
HSS = starts in single-detached housing in the current quarter, in units;
HSS(-j) = starts in single-detached housing lagged j quarters, in units; and
Qj = quarterly dummy variables such that Qj = 1 in the j-th quarter, j = 1,2,3, and = 0 otherwise.

Figures in parentheses below parameter estimates are asymptotic t-ratios; $\bar{R}^2$ is the goodness-of-fit measure adjusted for degrees of freedom; s, the standard error of estimate; DW, the Durbin-Watson statistic; and RHO, the first-order autocorrelation coefficient of residuals. All figures in parentheses under coefficient estimates and for RHO are their t statistics.

Judged by the magnitude of the $\bar{R}^2$, the equation fits well, but residuals are highly positively correlated. The maximum likelihood method was used to obtain the following results:

$$\underset{}{IHS/PNRC*100} = -\underset{(-3.71)}{1444450} - \underset{(-.09)}{5193.1*Q1} + \underset{(3.77)}{285467*Q2} + \underset{(3.88)}{287719*Q3}$$

$$+ \underset{(8.10)}{28.962*HSS} + \underset{(9.03)}{31.616*HSS(-1)} + \underset{(2.07)}{7.524*HSS(-2)}$$

$$+ \underset{(4.09)}{34.8595*YPD} \qquad (3.8b)$$

$\bar{R}^2 = .949$ $\qquad$ s = 668042
DW = 1.895

The reported $\bar{R}^2$, s, and DW above are based on the original data. There exists a strong seasonal variation in residential investment in new single-detached housing. The sum of lag coefficients for the starts variables implies that, if the lag pattern between the housing starts and residential investment remains constant over time, construction of a new single-detached house would result in residential investment of about $68,100 at the constant 1986 price. All coefficient estimates are significant except that of Q1 and have expected signs. Judged by the magnitude of $\bar{R}^2$, the fit of (3.8b) appears to be satisfactory.

The maximum significant lag coefficient is found at lag 2. Inclusion of additional lagged values of the HSS variable as regressors did not yield significant coefficient estimates nor improved the fit of the estimated equation.

(2) New investment in semi-detached housing

New residential investment equation for semi-detached housing estimated by least squares was as follows:

$$IHSD/PNRC*100 = -\underset{(-6.11)}{78721.0} - \underset{(-0.64)}{4574.1*Q1} + \underset{(1.79)}{11273.8*Q2} + \underset{(1.40)}{11039.6*Q3}$$

$$+ \underset{(6.89)}{17.274*HSSD} + \underset{(8.41)}{24.050*HSSD(-1)} + \underset{(2.03)}{5.809*HSSD(-2)}$$

$$+\ 4.887*HSSD(-3) + 0.24910*YPD$$
$$(1.98) \qquad (8.22) \qquad (3.9a)$$

$\bar{R}^2 = .932$ s = 13831.2
DW = .694 RHO = .666 (7.76)
Mean of IHSD/PNRC = 143944

where
IHSD = new residential investment in semi-detached housing, in thousands of current dollars; and
HSSD = starts of semi-detached housing, in units.

The fit is very good, but residuals are highly positively autocorrelated. The maximum likelihood method gave the following results:

$$IHSD/PNRC*100 = -\ 66595.0 - 2275.7*Q1 + 12627.9*Q2 + 12991.1*Q3$$
$$(-2.88) \quad (-0.51) \quad (3.10) \quad (3.05)$$

$$+\ 17.914*HSSD + 23.968*HSSD(-1) + 5.851*HSSD(-2)$$
$$(10.04) \quad (13.75) \quad (3.34)$$

$$+\ 3.167*HSSD(-3) + 0.21424*YPD \qquad (3.9b)$$
$$(1.78) \quad (3.56)$$

$\bar{R}^2 = .960$ s = 10559.9
DW = 1.98

where R^2 and other statistics are based on the original data. All starts variables have positive coefficients as expected and are significant. The sum of lag coefficients for the starts variables is equal to 50.9, implying that building a semi-detached unit would increase residential investment by about $55,000 at the constant 1986 price.

(3) <u>New investment in row housing</u>

The third component of new residential investment is for row housing. Least squares estimation yielded the following equation with lags up to four quarters as the preferred specification:

$$IHROW/PNRC*100 = -\ 145614 - 11907.3*Q1 + 2160.0*Q2 + 10924.1*Q3$$
$$(-12.4) \quad (-1.72) \quad (0.36) \quad (1.70)$$

$$+\ 15.539*HSROW + 16.122*HSROW(-1) + 7.546*HSROW(-2)$$
$$(10.4) \quad (9.72) \quad (4.54)$$

$$+\ 5.032*HSROW(-3) + 6.108*HSROW(-4) + 0.51108*YPD$$
$$(3.02) \quad (4.06) \quad (17.4)$$
$$(3.10a)$$

$$\bar{R}^2 = .961 \qquad s = 15108.6$$
$$DW = 1.00 \qquad RHO = .493\ (4.71)$$
Mean of IHROW/PNRC = 205655

where
IHROW = new residential investment in row housing, in thousands of current dollars; and
HSROW = starts in row housing in the current quarter, in units.

Although the fit is very good, residuals are highly positively correlated. The maximum likelihood method produced the following results:

$$\begin{aligned} IHROW/PNRC*100 = &- \underset{(-8.13)}{144183} - \underset{(-2.26)}{11303.2}*Q1 + \underset{(0.41)}{1980.9}*Q2 + \underset{(2.39)}{10528.1}*Q3 \\ &+ \underset{(12.0)}{15.824}*HSROW + \underset{(12.6)}{15.960}*HSROW(-1) + \underset{(5.82)}{7.329}*HSROW(-2) \\ &+ \underset{(3.95)}{4.995}*HSROW(-3) + \underset{(4.52)}{6.078}*HSROW(-4) + \underset{(10.5)}{0.51038}*YPD \end{aligned} \tag{3.10b}$$

$$\bar{R}^2 = .970 \qquad s = 13325.2$$
$$DW = 1.73$$

where R-squared and other statistics are based on the original data. The fitted equation looks very good. All housing starts variables up to a lag of four quarters have positive and significant coefficients. Inclusion of additional lagged values of the housing starts did not improve the fit of the estimated model.

Since the inclusion of many lagged variables could result in an imprecise estimate of the lag structure, the polynomial distributed lag (PDL) was examined as an alternative model. The most satisfactory specification was found to be a quadratic distributed lag model with the maximum lag of four quarters and AR(1) errors.

The maximum likelihood estimation of Eq.(3.10b) with a quadratic PDL, no end restrictions, and AR(1) errors gave the following results:

$$\begin{aligned} IHROW/PNRC*100 = &- \underset{(-8.33)}{141362} - \underset{(-2.28)}{11777.2}*Q1 - \underset{(-1.36)}{5982.7}*Q2 + \underset{(2.56)}{9426.8}*Q3 \\ &+ \underset{(13.1)}{17.206}*HSROW + \underset{(16.5)}{12.527}*HSROW(-1) + \underset{(10.3)}{8.945}*HSROW(-2) \\ &+ \underset{(8.86)}{6.459}*HSROW(-3) + \underset{(3.78)}{5.069}*HSROW(-4) + \underset{(11.0)}{0.50790}*YPD \end{aligned} \tag{3.10c}$$

$$\bar{R}^2 = .966 \qquad s = 14074.3$$
$$DW = 1.80$$

where R_2 and other statistics are based on the original data. It is also to be noted that, like other components in new residential investment, the row housing component also has a strong seasonal variation. All coefficients of the starts variables are positive and significant. Little difference is seen for the lag coefficients between (3.10b) and (3.10c). In terms of R^2 (3.10b) fits slightly better than (3.10c). Further, (3.10b) does not impose simplifying a priori restrictions on the lag coefficients. We therefore choose (3.10b) as the preferred specification. The sum of lag coefficients in (3.10b) is 50.2, implying that a unit increase in row-housing starts would increase residential investment by about $51 thousand at the constant 1986 price.

(4) New investment in apartment housing

The last but very important component of new residential investment is for apartment housing. When lagged values of housing starts up to the fourth lag were included, the least squares estimation yielded the following results:

$$\begin{aligned} IHAPT/PNRC*100 = &- \underset{(-6.43)}{474986} - \underset{(-1.37)}{52384.3*Q1} + \underset{(2.54)}{63171.1*Q2} + \underset{(2.08)}{65462.8*Q3} \\ &+ \underset{(5.96)}{9.3500*HSAPT} + \underset{(7.98)}{16.3514*HSAPT(-1)} + \underset{(2.60)}{5.2002*HSAPT(-2)} \\ &+ \underset{(1.77)}{3.1884*HSAPT(-3)} + \underset{(1.95)}{3.4414*HSAPT(-4)} + \underset{(10.9)}{1.9481*YPD} \end{aligned} \tag{3.11a}$$

$$\bar{R}^2 = .812 \qquad s = 75528.7$$
$$DW = .448$$
$$\text{Mean of } IHAPT/PNRC = 784399$$

where
IHAPT = new residential investment in apartment housing, in thousands of current dollars; and
HSAPT = starts of apartment housing in units.

Residuals are highly positively autocorrelated, and many insignificant coefficients estimates in Equation (3.11a) may be due to their biased standard errors. Applying the maximum likelihood method, we obtained the following results:

$$IHAPT/PNRC*100 = - \underset{(-3.11)}{549830} - \underset{(-3.04)}{47917.2*Q1} + \underset{(4.52)}{64233.8*Q2} + \underset{(4.81)}{70068.0*Q3}$$

$$+ \underset{(8.06)}{10.8120*HSAPT} + \underset{(13.1)}{17.3173*HSAPT(-1)} + \underset{(4.59)}{6.1529*HSAPT(-2)}$$

$$+ \underset{(2.56)}{3.3235*HSAPT(-3)} + \underset{(3.00)}{3.9214*HSAPT(-4)} + \underset{(4.40)}{1.9674*YPD} \quad (3.11b)$$

$\bar{R}^2 = .922$ $\quad$ $s = 48871.6$

$DW = 1.72$

where R^2 and other statistics are based on the original data. All coefficients of the starts variables are positive and significant.

Since Equation (3.11b) includes several lagged values of the dependent variable, a PDL model with an AR(1) error was tried. The most satisfactory specification was found to be a quadratic one containing lags up to four quarters and its ML estimation results were as follows:

$$IHAPT/PNRC*100 = \underset{(-2.98)}{-\ 517679} - \underset{(-2.38)}{42883.8*Q1} + \underset{(1.46)}{23234.9*Q2} + \underset{(5.49)}{73200.2*Q3}$$

$$+ \underset{(9.64)}{14.0665*HSAPT} + \underset{(10.6)}{11.3775*HSAPT(-1)} + \underset{(7.29)}{8.3516*HSAPT(-2)}$$

$$+ \underset{(4.76)}{4.9889*HSAPT(-3)} + \underset{(0.91)}{1.2893*HSAPT(-4)} + \underset{(4.85)}{1.9692*YPD} \quad (3.11c)$$

$\bar{R}^2 = .886$ $\quad$ $s = 58903.3$

$DW = 1.875$

where R^2 and other statistics are based on the original data. The time profile of reaction coefficients appears to be similar between (3.11b) and (3.11c). All starts variables have significant coefficient estimates except at the fourth lag. In terms of goodness of fit (3.11b) is better than (3.11c). Further, it does not impose dubious polynomial restrictions on the lag coefficients. We choose (3.11b) as the preferred model. The sum of lag coefficients in (3.11b) is equal to 41.5, implying that building a unit of apartment housing would increase residential investment by about $42,000 at constant 1986 prices. When included as regressors, additional lagged values of the dependent variable had insignificant or negative coefficient estimates.

Finally, new residential investment in all types of housing is defined simply by the following two identities:

$$IHM = IHSD + IHROW + IHAPT \quad (3.12)$$

and

$$IHNEW = IHS + IHM \quad (3.13)$$

where

IHM = new residential investment in multiple housing, in thousands of current dollars; and

IHNEW = residential investment in new housing, in thousands of current dollars.

The housing starts variables HSS, HSSD, HSROW, and HSAPT come from the part of the housing sector discussed in Chapter 2. The current and lagged values of the variables YPD, PNRC and the quarterly dummy variables Q1, Q2, and Q3 are exogenous to the model. The lagged endogenous variables included in this part of the model are lagged starts variables: HSS(-1), HSS(-2), HSSD(-1), HSSD(-2), HSSD(-3), HSROW(-1), HSROW(-2), HSROW(-3), HSROW(-4), HSAPT(-1), HSAPT(-2), HSAPT(-3), and HSAPT(-4).

3.4 Estimation Results of Other Residential Investment Equations

It is to be noted at the outset that modelling other residential investment is problematic as the quality of data, in particular, on conversions and improvements is suspect. Since the data on conversions and improvements are based on building permits and the latter capture mostly improvements over $20,000, the data on conversions and improvements should significantly undervalue residential investment in conversions and improvements.

As discussed in Section 3.2, various components in the category of other residential investment were modelled as consumption expenditures within the framework of the theory of aggregate consumption function. One of the most commonly estimated forms of the consumption function includes present personal disposable income and past patterns of consumer behaviour as independent variables. The latter are often represented by lagged consumption. Thus we write

$$C_t = a + b\ Y_t + d\ C_{t-1}, \tag{3.14}$$

where

C_t = consumption expenditure in period t, and

Y_t = personal disposable income in period t.

The aggregate consumption function in (3.14) may be justified by the permanent income hypothesis.

Two other possible determinants were also considered in modelling other residential investment: the rate of interest and "relative price." The rate of interest represents the opportunity cost of money spent on home improvements and other residential investment. The 91-day Canada Treasury bill rate (RTB) was used as the proxy for the interest rate variable. In all models for other residential investment, however, the RTB was found to be insignificant, and was excluded from the final model specification.

The relative price of residential investment was represented by the ratio of the housing component, CPIHT, of the all-items consumer price index (CPI) to CPI itself. Since CPIHT does not represent the actual construction cost, the basic construction wage rate index (Cansim code D477450) was tried as an alternative proxy for the price variable. Construction building material index (Cansim code D649830) could be another proxy but is available only for the period since January 1981, and was not tried in estimation.

It is often claimed that consumption and income should be measured on the per capita instead of aggregate basis. We computed regression estimates for both per capita and aggregate bases and found little significant differences. But the aggregate specification seemed slightly better than the per capita one on the basis of the goodness-of-fit consideration and residual analysis. As in the case of investment equations for new residential construction, the effective sample period for estimation is 1970:1 - 1990:4 (T = 84).

(1) Residential investment in conversions

Least square estimation results of the residential investment equation for conversions were as follows:

$$\underset{}{IHCON/CPI*100} = \underset{(-2.06)}{-\ 9469.4} + \underset{(2.79)}{5608.8*Q1} + \underset{(1.32)}{2199.1*Q2} + \underset{(1.56)}{3348.2*Q3}$$

$$+ \underset{(1.62)}{.03877*YPD} + \underset{(16.0)}{0.7369*IHCON(-1)/CPI(-1)*100} \qquad (3.15a)$$

$\bar{R}^2 = .777$ $\qquad$ s = 5662.9
Durbin's h = -2.37 $\qquad$ RHO = -.413 (-3.93)
Mean of the dep. variable = 15918.2

where
IHCON = residential investment in conversions, in thousands of current dollars;
CPI = all-items consumer price index, 1986 = 100;
CPIHT = housing component of CPI, 1986 = 100; and
YPD = aggregated personal disposable income in the current and three preceding quarters deflated by CPI, in millions of constant 1986 dollars;

Judged by $\bar{R}^2$, the fit is good, and all coefficient estimates are significant and have expected signs. However, the residuals show a strong negative autocorrelation. The maximum-likelihood method with an AR(1) error produced the following results:

$$IHCON/CPI*100 = \underset{(-2.05)}{-\ 5984.7} + \underset{(2.79)}{6168.8*Q1} + \underset{(1.32)}{1999.9*Q2} + \underset{(1.56)}{3464.4*Q3}$$

$$+ .01812*YPD + 0.87927*IHCON(-1)/CPI(-1)*100 \quad (3.15b)$$
(1.62) (16.0)

$\bar{R}^2 = .807$ $s = 5276.4$
DW = 2.01

where R^2 and other statistics are in terms of the original data. All coefficient estimates are significant. Both the relative price and the RTB variables turned out to be insignificant in both (3.15a) and (3.15b).

(2) Residential investment in improvements

The most significant component in the category of other residential investment is for alterations and improvements. The most satisfactory specification based on least squares regression was:

$$IHIMP/CPI*100 = 2887860 - 1057980*Q1 + 201584*Q2 + 658755*Q3$$
(1.42) (-15.5) (2.93) (9.52)

$$+ 10.8578*YPD - 3757130*CPIHT/CPI*100 - 21709.5*RTB \quad (3.16)$$
(17.7) (-2.19) (-1.99)

$\bar{R}^2 = .944$ $s = 221011$
DW = 1.77 RHO = .056 (.464)
Mean of the dep. variable = 19506270

where
IHIMP = residential investment in improvements, in thousands of current dollars.

All coefficient estimates in (3.16) are significant and have expected signs. The fit is also very good, and residuals are uncorrelated as indicated by the Durbin-Watson statistic of 1.77. Further, a rather large positive coefficient of the income variable YPD implies that investment in improvements is not only a significant component in household expenditures but pro-cyclical rather than counter-cyclical.

(3) Residential investment in cottages

The relative price variable was not found to be a significant determinant of residential investment in cottages. Least squares estimation results of the investment equation for cottages were

$$IHCOT/CPI*100 = - 22907.3 - 32626.7*Q1 + 132037*Q2 + 161694*Q3$$
(-1.10) (-2.05) (5.74) (15.2)

$$+ .17551*YPD + .37775*IHCOT(-1)/CPI(-1)*100 \quad (3.17a)$$
(3.36) (3.70)

$$\bar{R}^2 = .939 \qquad s = 20562.7$$
$$\text{Durbin's } h = 1.61 \qquad RHO = -.290\ (-2.69)$$
Mean of the dep. variable = 149233

where
IHCOT = residential investment in cottages, in thousands of current dollars.

Real personal disposable income and the lagged dependent variable both appeared to be significant determinants of the investment in cottages.

When corrected for a mild first-order negative autocorrelation in residuals by the maximum-likelihood method, the estimation results were not much different from those in (3.17a):

$$\begin{aligned} IHCOT/CPI*100 = &- \underset{(-3.38)}{62527.4} - \underset{(-.22)}{3006.5*Q1} + \underset{(8.92)}{180043*Q2} + \underset{(17.3)}{179865*Q3} \\ &+ \underset{(2.89)}{.113965*YPD} + \underset{(6.66)}{.602437*IHCOT(-1)/CPI(-1)*100} \end{aligned} \tag{3.17b}$$

$$\bar{R}^2 = .941 \qquad s = 20206.6$$
$$DW = 1.99$$

where R^2 and other statistics are in terms of the original data. This equation is chosen as the preferred one.

(4) <u>Residential investment in mobile homes</u>

The least squares estimation results were:

$$\begin{aligned} IHMOB/CPI*100 = &- \underset{(1.10)}{20366.0} - \underset{(-.12)}{752.7*Q1} + \underset{(10.36)}{67422.8*Q2} + \underset{(3.71)}{22902.9*Q3} \\ &- \underset{(-2.31)}{11410*YPD} + \underset{(21.4)}{0.89708*IHMOB(-1)/CPI(-1)*100} \end{aligned} \tag{3.18}$$

$$\bar{R}^2 = .917 \qquad s = 20530.0$$
$$\text{Durbin's } h = 1.58 \qquad RHO = .168\ (1.52)$$
Mean of the dep. variable = 99590.9

where
IHMOB = residential investment in mobile homes, in thousands of current dollars.

Residential investment in mobile homes appears to have a very strong inertia as indicated by a very large coefficient of the lagged dependent variable. As expected, the coefficient of the

income variable is found to be negative, and indicates the mobile homes to be an inferior good.

(5) <u>Residential investment -- acquisition costs</u>

The last component in other residential investment is acquisition costs. Least squares estimation of Equation (3.7) gave the following results:

$$
\begin{aligned}
IHACQ/CPI*100 = & - 26203.9 - 8183.2*Q1 + 12788.4*Q2 + 27991.6*Q3 \\
& \quad (-1.77) \quad (-1.00) \qquad (1.57) \qquad (4.26) \\
& + 1.8861*HCS + 4.3758*HCM - 4.8265*HCM(-1) \\
& \quad (3.95) \qquad (5.72) \qquad (-6.62) \\
& + .92343*IHACQ(-1)/CPI(-1)*100 \\
& \quad (33.4)
\end{aligned}
\tag{3.19}
$$

$\bar{R}^2$ = .956 s = 20821.2
Durbin's h = -.56 RHO = .031 (.26)
Mean of the dep. variable = 221518

where
IHACQ = residential investment in acquisition costs, in thousands of current dollars;
HCS = completions of single housing in the current quarter, in units; and
HCM = completion of multiple housing in the current quarter, in units;

Judged by $\bar{R}^2$, the fit is good, all coefficient estimates are significant and residuals show no autocorrelations. Inclusion of the lagged value of HCS did not make an improvement over (3.19). On the other hand, the lagged HCM has been retained in the equation even though its coefficient is of the wrong sign simply because its exclusion would adversely affect the goodness of fit. This sign issue should be further examined in the future research.

Two identities complete the specification of all variables in residential investment:

$$IHO = IHCON + IHIMP + IHCOT + IHMOB + IHACQ \tag{3.20}$$

and

$$IHTOT = IHNEW + IHO, \tag{3.21}$$

where
IHO = other residential investment, in thousands of current dollars; and
IHTOT = total residential investment, in thousands of current dollars.

The variables HCS and HCM are determined by the part of the housing sector model presented in Chapter 2 while the variables YPD, CPI, CPIHT, and seasonal dummies are exogenous to the model. Lagged endogenous variables included in the equations for other residential investment are CPI(-1), IHCON(-1), IHIMP(-1), IHCOT(-1), IHMOB(-1), and IHACQ(-1).

3.5 Ex Post Forecasts of Residential Investment

In this section we present the forecast results for four quarters of 1991 from the residential investment equations estimated and presented in the preceding sections. Since the 1991 data were not included in the estimation of the investment equations reported above, the post sample-forecasts for the four quarters in 1991 provide a test for the validity as well as the forecasting ability of the fitted equations. A note of caution is in order, however. The year 1991 was not a typical year and macroeconomic forecasting of the year would have a large margin of errors. First, in January a 7% GST was imposed on sales of goods and services except for a limited number of items, and hence the deflators used--PNRC and CPI--had a one-time jump in the first quarters of 1991. Furthermore, the Canadian economy had been in recession since 1990, and the housing sector of the economy was severely depressed in 1991.

The forecasting results presented are based on dynamic simulations in which (1) the endogenous variables in the housing sector and the mortgage market in Chapters 2 and 4 are treated as exogenous and (2) the values of the lagged endogenous variables of the residential investment sector are assigned those from the forecasts rather than the actual realizations of the variables (as in static or historical simulations).

3.5.1 Forecasts of New Residential Investment Variables

Table 3.1 presents the actual and forecast values for each of the four new residential investment variables for single-detached, semi-detached, row, and apartment housing.

Forecast errors for new residential investment varied from -0.04 % for row housing in 1991Q1 to 29.42% for semi-detached in the same quarter. When the quarterly forecasts are aggregated to the annual figures, they turn out to be much more accurate: -2.7% for investment in single-detached, -3.29% for semi-detached, -2.53% for row housing, and 14.76% for apartments. Investment in apartments decreased in real terms by 35.5% in 1991 over the 1990 level, and a one-year ahead over-forecast by 14.76% should not be considered as a poor forecast.

3.5.2 Forecasts of Other Residential Investment Variables

Table 3.2 presents the actual and forecast values for each of the five categories of other residential investment: conversions, improvements, cottages, mobile homes, and acquisition costs.

Although the estimated equations for the components of other residential investment fitted the sample data reasonably well, their forecasts did not turn out to be as good as for the new residential investment. The percentage error of forecast varied from -58.95% for investment in conversions in 1991Q1 to 73.63% for investment in cottages in the same quarter. Poor forecasts for 1991Q1 may be in part due to the sharp increase in CPI arising from the new GST and carried forward in dynamic simulation for forecasts for the subsequent quarters. For the aggregated annual forecasts, the percentage forecast errors were -0.31% for investment in conversions (IHCON/CPI), 15.21% for improvements (IHIMP/CPI), 17.14% for cottages (IHCOT/CPI), -11.29% for mobile homes (IHMOB/CPI), and -15.16% for acquisition costs (IHACQ/CPI).

Table 3.1

Actual and Forecast Values of New Residential Investment:

1991Q1 - 1991Q4

Variable	1991Q1	1991Q2	1991Q3	1991Q4	1991
IHS/PNRC*100 (based on Eq.(3.8b))					
Actual	1223531	1782700	2748326	2333500	8088057
Forecast	1439932	1893764	2422167	2106727	7862590
Error (%)	17.69	6.23	-11.87	-9.72	-2.79
IHSD/PNRC*100 (based on Eq.(3.9b))					
Actual	68013	110034	154472	166592	499111
Forecast	88020	106783	139298	148608	482709
Error (%)	29.42	-2.95	-9.82	-10.79	-3.29
IHROW/PNRC*100 (based on Eq.(3.10b))					
Actual	200595	217657	252189	297698	968139
Forecast	200679	221805	245380	275797	943661
Error (%)	-0.04	1.91	-2.70	-7.36	-2.53
IHAPT/PNRC*100 (based on Eq.(3.11b))					
Actual	523384	584967	642158	604238	2354747
Forecast	596336	685587	740756	679507	2702186
Error (%)	13.94	17.20	15.35	12.46	14.76

Table 3.2

Actual and Forecast Values of Other Residential Investment:

1991Q1 - 1991Q4

Variable	1991Q1	1991Q2	1991Q3	1991Q4	1991
IHCON/CPI*100 (based on Eq.(3.15b))					
Actual	31757	24439	28151	19075	103422
Forecast	21039	30797	25759	25508	103103
Error (%)	-58.95	26.02	-35.30	7.13	-0.31
IHIMP/CPI*100 (based on Eq.(3.16))					
Actual	1287540	2984933	3596215	2590837	10459525
Forecast	1997888	3300352	3720079	3032285	12050604
Error (%)	55.17	10.56	3.44	17.03	15.21
IHCOT/CPI*100 (based on Eq.(3.17b))					
Actual	36286	159791	183793	125869	505739
Forecast	63002	182510	256317	90588	592417
Error (%)	73.63	14.22	39.46	-28.03	17.14
IHMOB/CPI*100 (based on Eq.(3.18))					
Actual	18426	32160	46174	45346	142106
Forecast	15339	61133	29354	19346	125172
Error (%)	-16.75	90.09	-36.43	-57.34	-11.92
IHACQ/CPI*100 (based on Eq.(3.19))					
Actual	481094	631275	691690	611273	2415332
Forecast	329186	462627	620034	637391	2049238
Error (%)	-31.57	-26.71	-10.36	4.27	-15.16

APPENDIX 3A

Variable Definitions

IHS = new residential investment in single-detached housing, in thousands of current dollars;
IHSD = new residential investment in semi-detached housing, in thousands of current dollars;
IHROW = new residential investment in row housing, in thousands of current dollars;
IHAPT = new residential investment in apartment housing, in thousands of current dollars;
IHM = new residential investment in multiple housing, in thousands of current dollars;
IHNEW = residential investment in new housing, in thousands of current dollars;
IHCON = residential investment in conversions, in thousands of current dollars;
IHIMP = residential investment in improvements, in thousands of current dollars;
IHCOT = residential investment in cottages, in thousands of current dollars;
IHMOB = residential investment in mobile homes, in thousands of current dollars;
IHACQ = residential investment in acquisition costs, in thousands of current dollars;
IHO = other residential investment, in thousands of current dollars;
IHTOT = total residential investment, in thousands of current dollars;
HSS = starts in single-detached housing in the current quarter, in units;
HSS(-j) = starts in single-detached housing lagged j quarters, in units;
HSSD = starts of semi-detached housing, in units;
HSROW = starts in row housing in the current quarter, in units;
HSAPT = starts of apartment housing in units;
HCS = completions of single housing in the current quarter, in units;
HCM = completion of multiple housing in the current quarter, in units;
PNRC = the implicit deflator of investment in new residential construction, 1986 = 100;
CPI = all-items consumer price index, 1986 = 100;
CPIHT = housing component of CPI, 1986 = 100;
YPD = aggregated personal disposable income in the current and three preceding quarters deflated by CPI, in millions of constant 1986 dollars;
Qj = quarterly dummy variables such that Qj = 1 in the j-th quarter, j = 1,2,3, and = 0 otherwise.

4 The Mortgage Market

4.1 Introduction

In this section, the mortgage market is modelled. In so doing, three aspects of the market are examined: the number of units approved, the average loan per approved unit and mortgage interest rates. In the first two cases, estimates are provided for single and multiple units, for new and existing houses and for NHA versus conventional loans. Mortgage interest rates are estimated for chartered bank typical rates for 1 year, 3 year and 5 year terms, as well as the 5 year conventional mortgage rate (arguably the most important of these rates).

Because the institutions underlying the mortgage market are so important, the next section provides an overview of the changes that have occurred. There have been several important changes to legislation that have an impact on the mortgage market and, of course, these must be introduced into the specification adopted or, at least, the time period over which any analysis is undertaken must take note of these changes. Otherwise, unless these omitted institutional variables are uncorrelated with the variables included in the specification, bias will be introduced into the parameter estimates.

The outline of this chapter is as follows: in the next section, an overview of the institutional changes that could have an impact on the mortgage market is presented. Section 4.3 sets out the theory underlying the equations to be estimated. Sections 4.4, 4.5 and 4.6 present results for the units approved, average loan per unit and mortgage rates respectively.

4.2 Background

There have been many changes in the institutional structure underlying the mortgage market over the last 25 years. These changes must be taken into consideration in modelling loan approvals, the average loan per unit and, particularly, the determination of mortgage rates.

For the period to the early 1970s, some of these changes are reviewed in Hatch (1975). To highlight the major changes in the institutions before the period of analysis in this study, the revision of the Bank Act in 1954 and the National Housing Act (NHA) resulted in a movement away from direct CMHC lending to consumers and towards insuring loans made by approved lenders. In addition, the chartered banks were allowed to hold NHA mortgages.

The next major set of changes occurred in the second half of the 1960s. In November, 1966 the maximum interest rate on insured NHA

loans moved to a formula that was tied to the long term Government of Canada average bond yield. The formula was revised in September, 1967 to allow for a larger spread between the NHA rate and the long term rate (the NHA rate could be up to 2.25 percent above the long term rate). The 1967 revision to the Bank Act permitted the chartered banks to make conventional residential mortgages, but limited the amount of those loans to no more than 10 percent of their domestic deposits. The combination of changes to the NHA and the Bank Act put more reliance on interest rates in determining mortgage investment rather than on other rationing devices as in 1966 and before. An indication of the effect of these changes on mortgage lending, as well as the need for more flexibility in the way mortgage rates were set, was provided by the fact that in each quarter of 1968, the NHA mortgage rate hit the ceiling of 2.25 percent above the long term bond yield.

On June 27, 1969, the NHA maximum interest rate was abolished and the mortgage rate was allowed to find its own level in the marketplace. This made NHA mortgages much more attractive to potential investors, since their yields became competitive with yields from other financial instruments. Also in 1969, an amendment to the Canada Interest Act allowed for the trust companies to match their assets (for example, their mortgages) against their liabilities (for example, their trust certificates that provided them with a source of loanable mortgage funds). This permitted the trust companies to expand their mortgage loans considerably. There were several changes to the eligibility requirements under the NHA including the extension of NHA insured mortgages to existing housing (in addition to new housing) and 5 year renewable mortgages were permitted.

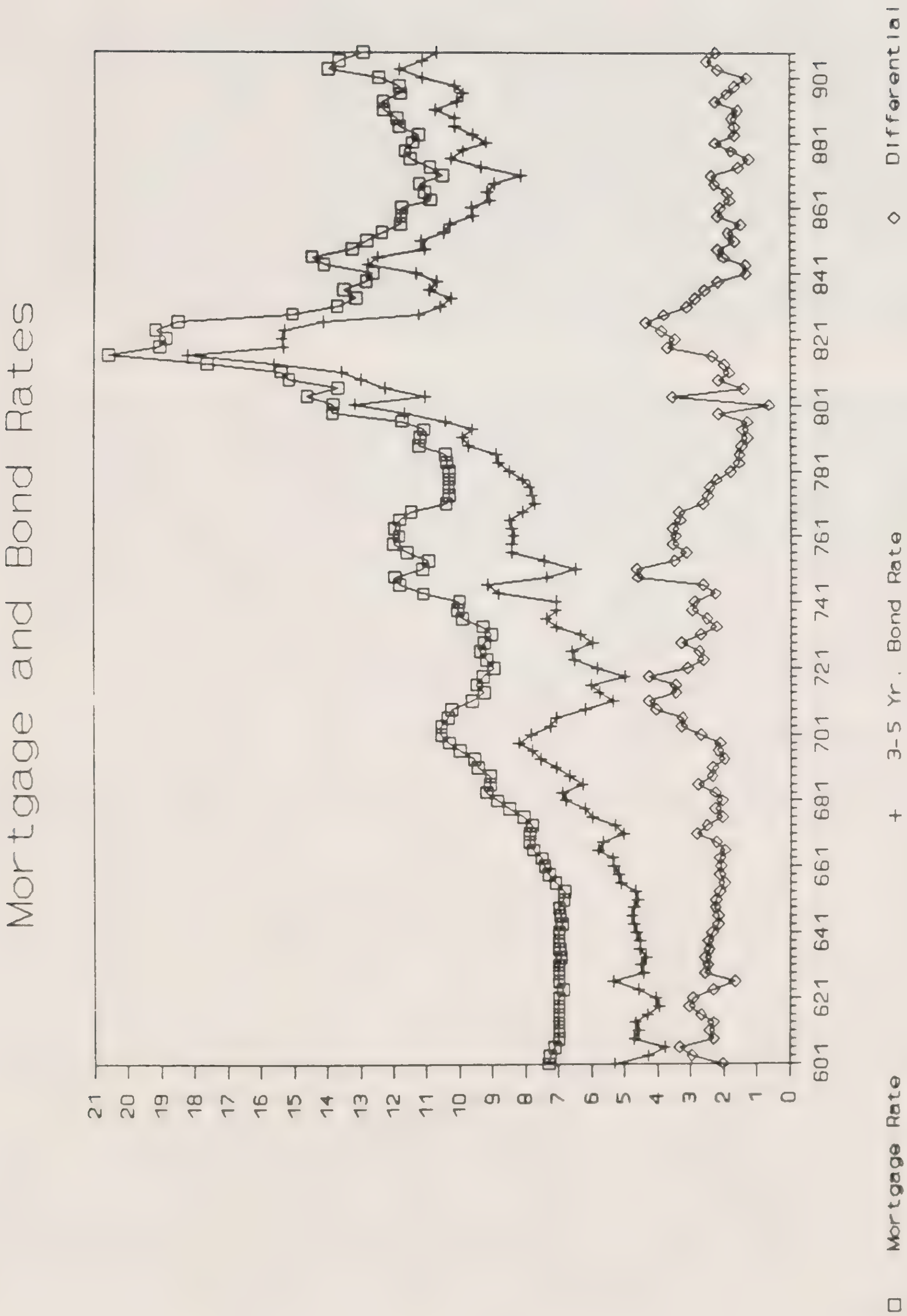
In 1973, the Minister of Finance informally instructed the chartered banks to keep mortgage rates at 10 percent. Also at this time the Assisted Home Ownership Program (AHOP), which provided loans and grants to low income families with one or more dependent children, was started. In June, 1974, CMHC announced new guidelines whereby the maximum loan under the NHA was cut to $40,000 in an attempt to have lenders channel more funds for financing moderately priced homes. In the latter part of the 1970s, the Anti-Inflation Board (AIB) was in place (which may have moderated inflation generally and slowed the increase in house prices) and both AHOP and the Assisted Rental Program (ARP) increased NHA activity.

In 1980, the Bank of Canada reverted to a floating Bank Rate and this led to changes in the spread between mortgage rates and bond rates. Sharp increases in interest rates occurred in 1981 with the 5-year conventional mortgage rate peaking at 21.46 percent in September before falling to 17.79 percent in December. The Canada Mortgage Renewal Plan (CMRP) was announced in November, 1981 and was designed to assist homeowners with financing problems on their renewal of mortgages between September, 1981 and November 12, 1982

(later extended to December 1983). The Canadian Home Ownership Stimulation Program (CHOSP) was established to provide grants of $3,000 to new home buyers in 1983 (although the program was terminated in May, 1983). After the volatile interest rates of the early 1980s, the term of mortgages was significantly reduced. However, beginning in 1985, 5-year mortgage terms again appeared and, in 1986, mortgage-backed securities (MBS) appeared. MBS were claims on the payment stream from a pool of (insured) mortgage loans and they were designed to foster the re-appearance of mortgage terms longer than 5 years. The first pool of these MBS appeared in 1987 and the number of pools in 1989 more than doubled the combined pools of 1987 and 1988.

It is useful to overview these changes through a graph of the 5-year conventional mortgage rate, the 3-5 year Government of Canada bond rate and their differential. These are set out in Figure 4.1 for the period 1960, quarter 1 through 1990, quarter 4. What is particularly interesting in this figure is the relative stability of the differential between the mortgage rate and the bond rate. Through 1969 the differential was very stable in line with the policy of tying the maximum mortgage rate to the long term Government of Canada bond yield. In the period 1970-72, fluctuations in the differential were likely due to de-coupling of the mortgage rate from the Government of Canada average long term bond rate. The increased variance in 1980 was likely caused by the change in Bank of Canada policy which led to a floating Bank Rate. Especially noteworthy, however, is substantially reduced variance of the differential in the period from 1984, quarter 1 through 1990, quarter 4.

In sum, changes in regulations concerning the mortgage market, typically allowing more freedom for the chartered banks, led to a large increase in the share of residential mortgage credit held by the chartered banks. In the first quarter of 1990, the chartered banks held over 52 percent of the residential mortgage credit -- an increase from approximately 10 percent in 1970. In addition, the decade of the 1980s was characterized by a growing diversity of mortgage types and alternatives including shorter term mortgages, improved pre-payment privileges, variable rate mortgages, etc. Finally, rising house prices have been financed by ever increasing sources of mortgage funds as is evidenced by the dramatic rise in the size of the average loan per dwelling unit.



Mortgage and Bond Rates
Mortgage Rate
3-5 Yr. Bond Rate
Differential

4.3 Modelling the Mortgage Market: Some Theory

In effect, there are two routes that could be followed in specifying equations in the mortgage market. One could follow Smith (1974) and model the supply of mortgage credit across the financial institutions. This would assume that supply constraints are an important part of determining the availability of mortgages and, therefore, mortgage rates. This was obviously the case when there were restrictions on what chartered banks could do with their assets and when the mortgage rate was tied to the average Government of Canada long term bond rate. The other route, assumes that the mortgage market is demand driven. That is, the demand for new mortgages depends on housing starts (and completions) and resales. This approach assumes that demand determines the quantity and value of mortgages and the mortgage rate is determined by other aggregate economic factors (including the movement in the rates on competing financial assets).

For completeness, both approaches are outlined here. However, there can be little doubt that since the early-1970s the mortgage market has not been constrained on the supply side. In effect, the mortgage rate is determining the demand for mortgage approvals. That leaves the issue of specification of the mortgage rate. Are there constraints on the availability of mortgage funds that push up the mortgage rate in response to an increase in demand or does the mortgage rate adjust through a term structure approach that leaves it in line with other competing financial instruments? Both possibilities are explored in Section 4.3.3.

4.3.1 The Supply of Mortgage Loans

The supply of mortgage funds comes from a variety of organizations including private financial institutions, the government and co-operatives and individuals. However, since private financial institutions (including chartered banks, trust companies, life insurance companies and mortgage loan companies) form the bulk of the supply of mortgage funds, the behaviour of these institutions should be modelled.

Some may suggest that the supply of mortgage loans is infinitely elastic. In such a world, the demand for loans determines the volume while the overall economic environment determines the interest rate. However, the reality of the market suggests that there are restrictions which result in an upward sloping supply function for mortgage loans. That is, after some volume of mortgage lending, the mortgage rate must rise in order to encourage financial institutions to increase the flow of mortgage credit. With this view of the world, the behaviour of the lending institutions must be modelled.

To model this behaviour we must recognize that financial

institutions want to allocate their total assets in such a way as to maximize profits. This is known as the portfolio decision and deals with how the total assets of the financial institutions are allocated across financial instruments depending on their rates of return.

In practical terms, one must differentiate among the assets financial institutions can hold (for example, government bonds and bills, corporate bonds, personal loans, mortgage loans, etc.) and then allocate the exogenous total assets of these institutions across the available investments. The share of total assets allocated to mortgages will depend on the relative rates of return on the investment. Assets of the financial institutions can include liquid assets, such as Government of Canada Treasury bills and bonds, call and short loans, as well as less liquid assets, such as general loans, residential and non-residential mortgages, leasing receivables and holdings of corporate, provincial and municipal securities.

Following Smith (1974), assume that a financial institution has a desired portfolio target for mortgage loans outstanding (M^*) and, through a partial adjustment model, it adjusts its actual holding of mortgage loans outstanding (M) towards this desired level with speed of adjustment coefficient γ as given by equation (4.1):

$$M_t - M_{t-1} = \gamma(M^*_t - M_{t-1}) \tag{4.1}$$

Next, assume that the desired holdings of mortgage loans outstanding depends on the assets (A) of the financial institution, the rate of return on mortgages (RM), the rate of return on competing assets (RB) and other characteristics of the institutions (X). It is assumed that bonds are the major alternative to mortgage investment for financial institutions and, therefore, RB is a bond rate. Hence,

$$M^*_t = f(A_t, RM_t, RB_t, X_t) \tag{4.2}$$

Estimation could be undertaken by substituting (4.2) into (4.1). However, this would miss the fact that there is a difference between the desired stock of mortgages and mortgages outstanding. This arises because there are lags between commitments and disbursements. New commitments are given by mortgage approvals (MA). Since these are a gross concept some account must be made for expected principal repayments (PR) since financial institutions would want to make approvals to account for some of the repayment that occurs. In addition, we also have to take into account disbursements (D). That is, as Smith indicates, there is a difference between when the financial institution commits to making the mortgage loan and the actual disbursement of the funds. Consequently, financial institutions may want to alter their current mortgage approvals to account for previous mortgage commitments which have not yet been disbursed. Therefore, we can

re-write (4.2) as

$$MA_t = \gamma(M^*_t - M_{t-1}) + \beta\ PR_t + \epsilon\ D_t \tag{4.3}$$

Finally, expected principal repayments likely depend on the mortgage interest rate and on the previous outstanding stock of mortgages. Similarly, disbursements depend on previous approvals (or the previous outstanding stock). This gives an equation for estimation for mortgage approvals as

$$MA_t = g(A_t, RM_t, RB_t, X_t, M_{t-1}) \tag{4.4}$$

(An alternative specification would include a distributed lag on MA on the right hand side of this expression rather than the lagged outstanding stock.)

Equation (4.4) would be estimated for the major actors in the mortgage market: the chartered banks, the life insurance companies, the trust companies and the mortgage loan companies. Given the use of quarterly data, different lag formulations might be considered (in particular, it is likely that a distributed lag will be required on the interest rates (or the interest rate differential to reduce multicollinearity)). The important result from these equations is the interest rate elasticity. That is, it is the responsiveness of the supply of mortgage loans (approvals) to increases in the mortgage interest rate that can be used to assess the supply side of the market.

From these results, it will be possible to obtain the stock of residential mortgage credit and the residential mortgage credit outstanding by identity as the sum of the corresponding figures across financial institutions.

4.3.2 The Demand for Mortgage Loans

The other approach to follow is to assume that mortgage approvals are determined by the demand for mortgages and the financial institutions supply these mortgage loans at rates given by aggregate economic behaviour. In this case, we relate approvals directly to the determinants of demand. Furthermore, it is important to make a distinction between the demand for mortgages that arise from new houses and those from existing houses.

Quite often the demand for mortgage loans is assumed to be proportional to the demand for the stock of houses (or the services provided by the stock). While this is a useful starting point, it is important to allow all interactions in the housing market to influence the demand for mortgage loans. In effect, the demand for mortgage loans depends on variables that influence both the demand for and supply of housing services.

Fallis (1985) suggests a specification for the demand for mortgage loans that includes permanent real family income, the stock of housing per family, the conventional mortgage rate and the industrial or government bond rate. As such it includes elements which affect both the demand and supply sides of the housing market. In addition, government policies which alter the demand or supply of housing services must also be incorporated in this specification.

The demand for new housing mortgage loans in dollars (DMAN) is a function of real permanent household disposable income (YPD/HH), per household stock of new dwelling units (STN/HH), the mortgage rate (RM), and the cost of alternative funds, as proxied by the long term government bond yield (RB). The inclusion of RB in these equations represents the opportunity cost of obtaining a mortgage (that is, it represents the return on other assets in which households can invest their wealth).

$$DMAN_t = h((YPD/HH)_t, (STN/HH)_t, RM_t, RB_t) \tag{4.5}$$

Similarly, the demand for existing housing mortgage loans (DMAE) is a function of the same variables, with the exception that the stock of existing housing (STE) is used.

$$DMAE_t = h((YPD/HH)_t, (STE/HH)_t, RM_t, RB_t) \tag{4.6}$$

Again, since this relationship is estimated with quarterly data, different lag structures must be explored in order to differentiate between the short run and adjustment to the long run.

While estimation on the supply side as outlined in Section 4.3.1 must be undertaken in money terms (since the specification is, in effect, an asset allocation model), on the demand side other options are possible. For example, the demand for mortgage loans can be in terms of number of units. In addition, the specification can be estimated for new houses versus existing houses. For new housing mortgage loans in units (DUNITN), a specification would be based on a distributed lag of housing starts (HS), the mortgage interest rate (RM) and the cost of alternative funds (RB):

$$DUNITN_t = h(HS_t, RM_t, RB_t) \tag{4.7}$$

For existing houses, the approval of mortgages in units (DUNITE) would depend on a distributed lag of resale units sold (RESALE) and the same interest rates as for new housing:

$$DUNITE_t = h(RESALE_t, RM_t, RB_t) \tag{4.8}$$

Alternatively, equation (4.8) could be specified based on the stock of houses, since in any time period, some of these houses will be up for re-financing. That is, not only does the re-sale market influence the number of existing houses with mortgage approvals,

but a proportion of the existing stock must also be re-financed (that is, there are renewals).

Finally, equations (4.7) and (4.8), can be thought of as long run relationships. In practice, the market will adjust, over time, to this long run position. There are a number of ways to incorporate this adjustment. One possibility is through a partial adjustment model. In this case,

$$DUNITN_t - DUNITN_{t-1} = \tau(DUNITN^*_t - DUNITN_{t-1}) \quad (4.9)$$

where $DUNITN^*_t$ is the theoretically 'correct' function from equation (4.7). A similar equation would be appropriate for existing units. Alternatively, polynomial distributed lags (PDLs) on the explanatory variables in (4.7) or (4.8) to allow for adjustment from the short to the long run could be incorporated.

An advantage of estimating stochastic equations for the number of units is that it also permits the modelling of the average mortgage loan per unit. As Goldberg (1983) notes, the average mortgage loan per unit has followed the movement in house prices very closely. Defining AVLOANN = DMAN/DUNITN and AVLOANE = DMAE/DUNITE as the average mortgage loan on new and existing housing respectively, we would model

$$AVLOANN_t = k(PRICEN_t, RM_t) \quad (4.10)$$

$$AVLOANE_t = k(PRICEE_t, RM_t) \quad (4.11)$$

where PRICEN is the price of new houses as proxied by the new house price index (NHPI) and PRICEE is the price in the resale market as given by the MLS price (MLSP). Again a distributed lag formulation on the prices and interest rates may be required. The mortgage rate is included in an effort to allow for substitution between a larger down payment and, therefore, a lower mortgage loan when interest rates are high.

When estimating demand for units and average loan per unit, equations (4.5) and (4.6) would not be estimated. They would be obtained by identity:

$$DMAN_t = DUNITN_t * AVLOANN_t \quad (4.12)$$

$$DMAE_t = DUNITE_t * AVLOANE_t \quad (4.13)$$

4.3.3 The Determination of Mortgage Rates

There are two approaches to modelling mortgage interest rates. One is based on the demand-supply mechanism outlined in the previous two sections while the other follows a term structure approach to mortgage rate determination.

From the previous two sections, the mortgage rate could be determined through an adjustment towards equilibrium in the mortgage market. To begin, the total supply of mortgage approvals can be found by summing equation (4.4) across financial institutions. That is,

$$SMA_t = \Sigma_i\ MA_{it} = s(RM_t,\ RB_t,\ \Sigma_i A_i,\ \Sigma_i M_{it-1}) \tag{4.14}$$

Equation (4.14) sums across the financial institutions that supply of mortgages (of which the main sources are chartered banks, trust companies, mortgage loan companies and insurance companies). Then from the previous section, the total demand for mortgage approvals is given by $DMAN_t + DMAE_t$ (whether these components are obtained through behavioral relationships or through identity). Equating total demand and supply and solving for the mortgage rate, we obtain:

$$RM_t = s((YPD/HH)_t,\ (STN+STE/HH)_t,\ RB_t,\ \Sigma_i A_i,\ \Sigma_i M_{it-1}) \tag{4.15}$$

This would provide an equation for the equilibrium mortgage rate. However, since the mortgage market may not always be in equilibrium, there may be credit rationing and therefore the mortgage rate must adjust towards the equilibrium. In this case, the change in the mortgage rate should depend on excess demand (or supply) in the mortgage market. There are a couple of ways to do this: one is through a partial adjustment model where the actual mortgage rate adjusts to the equilibrium rate over time through speed of adjustment coefficient δ. Here, equation (4.15) would represent the equilibrium mortgage rate, say RM^*_t, and then adjustment to the actual rate would take the form:

$$RM_t - RM_{t-1} = \delta\ (RM^*_t - RM_{t-1}) \tag{4.16}$$

Alternatively, more lags could be introduced on the explanatory variables in equation (4.15).

With the movement over the last fifteen years towards shorter term mortgages (as a result of high and variable inflation rates), it is necessary to model mortgage rates with different terms. In particular, it is desirable to model the 1, 3 and 5 year mortgage rates. One way to accomplish this would be to use the specification given by equation (4.15) for each of the three rates. In some sense, this would be like modelling segmented markets. The difficulty with this approach is that it does not exploit the known relationship among interest rates of different terms.

This leads to the other approach often followed in modelling interest rates of different maturity lengths. The underlying theory is based on the term structure of interest rates. Following the expectations theory of the term structure, the mortgage rates in different terms would be related to expected future short term

rates as proxied by current and past short terms rates (that is, an adaptive expectations scheme). Alternatively, as Smith (1974) suggests, the longer term mortgage rate (e.g. the 5 year rate) could be related to a long term industrial or government bond rate.

While the approach that uses disequilibrium in the mortgage market to determine the mortgage rate (given by equation (4.16)) has good theoretical properties and has an easy interpretation, often for forecasting it can cause problems. To eliminate this problem, Smith, for example, simply relates the mortgage rate to the lagged long term bond rate and the change in that rate.

The choice of modelling approach has implications for the way the demand and supply specifications are made. Important in this regard are the need for consistency between the projections of demand for and supply of mortgage loans and the mortgage rate. In effect, in the long run the parameter estimates must be such that the market clears.

4.3.4 A Convenient Approach

While the above sub-sections provide different views of the mortgage market, in the following three sections estimates of equations are presented. This requires a decision on the structure of the model to be built. In what follows, we assume that there is no constraint on the supply side (as there likely was in the 1960s). Therefore, we model units approved based on housing starts and the mortgage rate. The average loan approved is based on the new house price index and the mortgage rate. The mortgage rate itself, is determined through a term structure approach. In this sense, the model is somewhat eclectic. However, it does seem to perform quite well. In Sections 4.4, 4.5 and 4.6 results are set out for the number of units approved, the average loan per approved unit and the mortgage rate.

4.4 Results for the Number of Units Approved

The approach followed here is on the demand side of the mortgage market as set out in Section 4.3.2. In the case of number of units approved for mortgage loans, the explanatory variables include housing starts, the mortgage rate (in order to maximize the sample size, the 5-year conventional mortgage rate was used) and either a time trend (which has the value 1 in 1961:1) or the proportion of the population aged 25-34. The specification adopted has a constant elasticity for approved units with respect to housing starts in the short run while the long run elasticity is restricted

to be one.[13] The constraint on the long run elasticity ensures that, after all adjustments, a proportional increase in starts is translated into the same proportional increase in approvals. The elasticity with respect to the mortgage rate is allowed to vary over the sample. There can be little doubt that the very high interest rates in the early 1980s had a different effect on units approved and, therefore, the elasticity should vary through the sample.

The basic specification makes units approved a function of housing starts and the five-year conventional mortgage rate for new single units and new multiple units for both conventional and NHA mortgages. The sign expectations are that housing starts should influence approvals positively, while the mortgage rate should have a negative effect on approvals. As described in the theoretical section, both polynomial distributed lags (PDLs) and partial adjustment models were attempted. The choice of which lag structure to adopt is an empirical one, but it turned out that PDLs had less predictive power than the lag structure implied by a partial adjustment model. While the lagged dependent variable which appears as an explanatory variable in the partial adjustment model can pose econometric problems (in particular, in the face of autocorrelation, the parameter estimates may be biased), the introduction of dynamics presents an important element in the modelling of mortgage approvals. Therefore, in this study, the partial adjustment model results are presented.

In addition, since there have been many changes in the mortgage market over the time period of analysis, especially with regard to the setting of mortgage rates and government programs designed to stimulate the housing market (described in Section 4.2), care must be taken in specifying the relationships. In order to capture the effect of having the mortgage rate determined by market forces (rather than being constrained to the Government of Canada long term bond rate), an interactive dummy variable was entered into the specification. Of course, it is difficult to identify the exact point where the structural change had an effect in the market after the mortgage rate was freed in 1969; however, it is likely that this took a few years. Consequently, an interactive dummy variable (that is, a slope dummy on the mortgage rate) beginning in the first quarter of 1973 is included in some regressions. While the adjustment to changes in mortgage rates was undoubtedly gradual during the early part of the 1970s, the results presented in this report show that the use of this interactive variable is important with regard to mortgage approvals of housing units. An intercept

---

[13] It should be noted that the use of the log transformation means that the share of units approved out of starts, in the long run, is a function of the quarterly dummies and the mortgage rate. In the short run, the share varies through the sample due to the use of a partial adjustment model.

dummy variable (beginning in 1973) was also included in the regressions, but was typically insignificant.

In addition, there has been an important shift, over time, towards conventional mortgages and away from NHA financed mortgages. This shift could be caused by demographic factors -- since there is a growing proportion of move-up buyers that is demographically induced. Both a demographic variable (the proportion of the population aged 25-34) and a simple time trend were included to account for this gradual change. For conventional units approved, this time trend should enter positively, while for NHA units approved it should enter negatively.

In the results that follow, the variable definitions are included in Appendix 4A. In the equations presented, figures in parentheses under the estimated coefficients are absolute values of the t-statistics.

4.4.1 Mortgage Approvals for New Single Units

For approvals of new single units, the sample period for both Conventional and NHA units was 1969, quarter 2 through 1990, quarter 4. The results are presented in equations (4.1) and (4.2). As these results show, the interaction between the mortgage rate and the dummy variable beginning in 1973 is significant in both cases. This is a reflection of the importance of the change that occurred in the mortgage market during the period of the late 1960s and early 1970s.

$$
\begin{aligned}
(4.17)\quad \log(\text{MLANCONS}) = & \underset{(5.36)}{-1.1778} + \underset{(6.87)}{0.4589{*}Q1} + \underset{(5.06)}{0.3176{*}Q2} \\
& - \underset{(1.41)}{0.0814{*}Q3} + \underset{(8.29)}{0.6784{*}\log(\text{HSS})} - \underset{(5.31)}{0.0740{*}\text{RMCON5YR}} \\
& + \underset{(4.11)}{0.0337{*}\text{D73}{*}\text{RMCON5YR}} + \underset{(2.05)}{0.0022{*}\text{TIME}} + \\
& + \underset{(3.93)}{0.3216{*}\log(\text{MLANCONS}(-1))}
\end{aligned}
$$

$\overline{R}^2 = 0.8545$ Mean of Dependent Variable = 8.0788
h = 2.23 Std. Error of Regression = 0.1867

$$
\begin{aligned}
(4.18)\quad \log(\text{MLANNHAS}) = & \underset{(2.70)}{-0.6276} - \underset{(2.37)}{0.2138{*}Q1} + \underset{(2.89)}{0.2519{*}Q2} \\
& - \underset{(2.33)}{0.1749{*}Q3} + \underset{(3.94)}{0.3037{*}\log(\text{HSS})} + \underset{(1.01)}{0.0178{*}\text{RMCON5YR}} \\
& - \underset{(2.28)}{0.0235{*}\text{D73}{*}\text{RMCON5YR}} - \underset{(1.41)}{0.0023{*}\text{TIME}}
\end{aligned}
$$

$$+ 0.6963*\log(MLANNHAS(-1))$$
$$(9.03)$$

$\overline{R}^2 = 0.8198$ Mean of Dependent Variable = 7.27135
$h = 1.49$ Std. Error of Regression = 0.2482

Also note that the estimated coefficients on the time trend meet our priors -- positive for conventional approvals and negative for NHA approvals. For each quarter, the percentage increase in conventional units approved is 0.22, while the decrease in NHA units approved is 0.23. These percent changes are constant through the sample period.

Both equations (4.17) and (4.18) were re-estimated using housing completions rather than housing starts with the other variables remaining the same. However, this substitution resulted in a deterioration in performance. Consequently, only the results using starts are presented here. This result may well reflect the trend in the Canadian housing market to ensure that a potential new house buyer had the financing before the house was started.

Three other specifications were considered. First, the restriction on the long run elasticity with respect to housing starts was relaxed. Not surprisingly, this resulted in an improvement in the goodness of fit, but since it makes more sense for all starts to eventually result in approved units, the restricted long run elasticity was retained. Second, instead of the time trend, the percent of the population aged 25-34 was substituted in the specification. While this specification led to a slight improvement in goodness of fit for conventional single approvals (but not for NHA approvals), forecasting with this variable is likely to be more difficult than a simple time trend. Finally, because of a potential timing delay between starts and units approved, a lag on housing starts was incorporated. However, in both cases, there was a significant deterioration in goodness of fit. This may well suggest that starts are turned into units approved within the quarter.

In order to interpret these results with respect to housing starts and the mortgage rate, it is useful to consider the elasticities implied by the estimated coefficients. These elasticities are set out in Table 4.1. While the long run elasticity with respect to housing starts was constrained to one, the short run elasticity is the coefficient on the logarithm of housing starts. The elasticities with respect to the mortgage rate were not constrained and, therefore, change throughout the sample. Table 4.1 presents these elasticities evaluated at the sample means. The long run elasticity is computed as the estimated coefficient on the mortgage

Table 4.1

Elasticities for Mortgage Loan Approvals for New Single Dwellings in Units

	Conventional		NHA	
	Short Run	Long Run	Short Run	Long Run
With Respect to:				
Housing Starts	0.6784	1.0000	0.3037	1.0000
Mortgage Rate	-0.4864	-0.7170	-0.0688	-0.2264

Notes:

The elasticities on housing starts in the long run are constrained to be 1 and are constant through the sample in the short run. The elasticities with respect to the 5-year conventional mortgage rate are calculated at the sample means.

Source: based on the estimated coefficients presented in equations (4.17) and (4.18).

rate divided by (1-estimated coefficient) on the lagged dependent variable (all multiplied by the average mortgage rate over the sample period).

Since the mortgage rate elasticities do vary through the sample, it is useful to examine the movement of these elasticities over the sample period. These are set out in Figures 4.2 and 4.3 for conventional and NHA new single units approved respectively. In these figures the elasticity of units approved with respect to the mortgage rate are indicated for both the constrained (that is, where the long run elasticity of units approved with respect to housing starts is constrained to one) and unconstrained model. As these figures show, these elasticities do vary throughout the sample, most notably in the 1980-1983 period. Also, the role of the mortgage rate changes significantly at the time of the structural change in the mortgage market in 1973, quarter 2.

An alternative way to view the dynamics introduced into these equations is through the effect of a permanent versus transitory change in the variables. Figures 4.4 and 4.5 set out the effect of a once-and-for-all 10 percent increase in housing starts (a permanent change in housing starts) and an increase in housing starts that lasts for only one quarter (a transitory change).

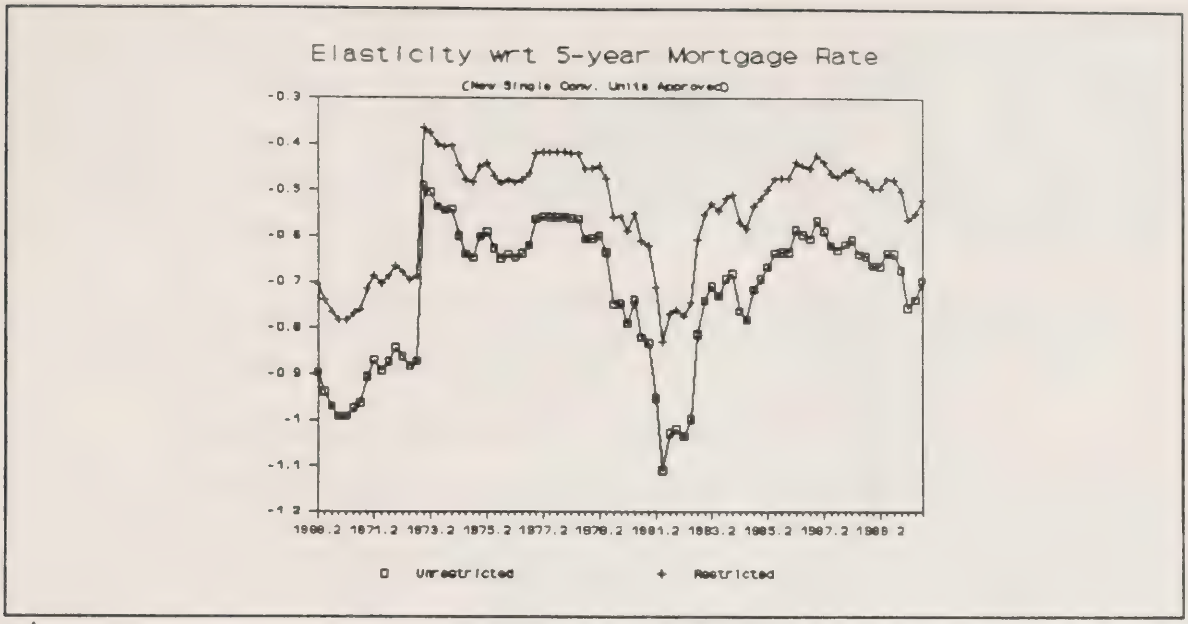


Figure 4.2

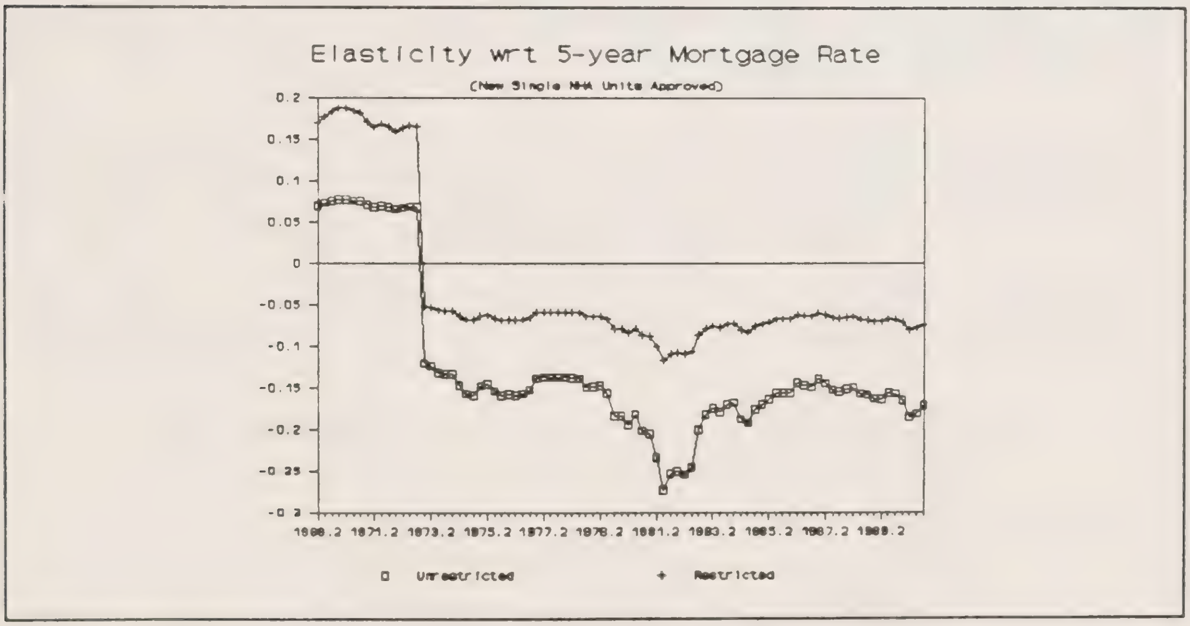


Figure 4.3

NOTE: The restricted plot refers to the case where the long run elasticity on housing starts is constrained to 1.

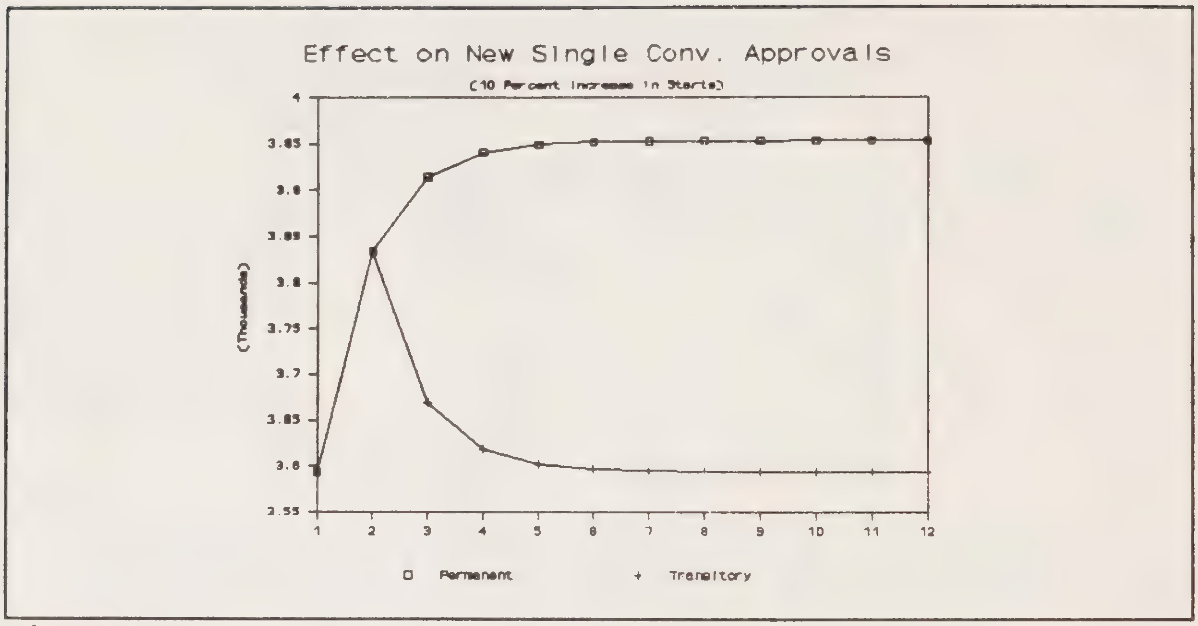


Figure 4.4

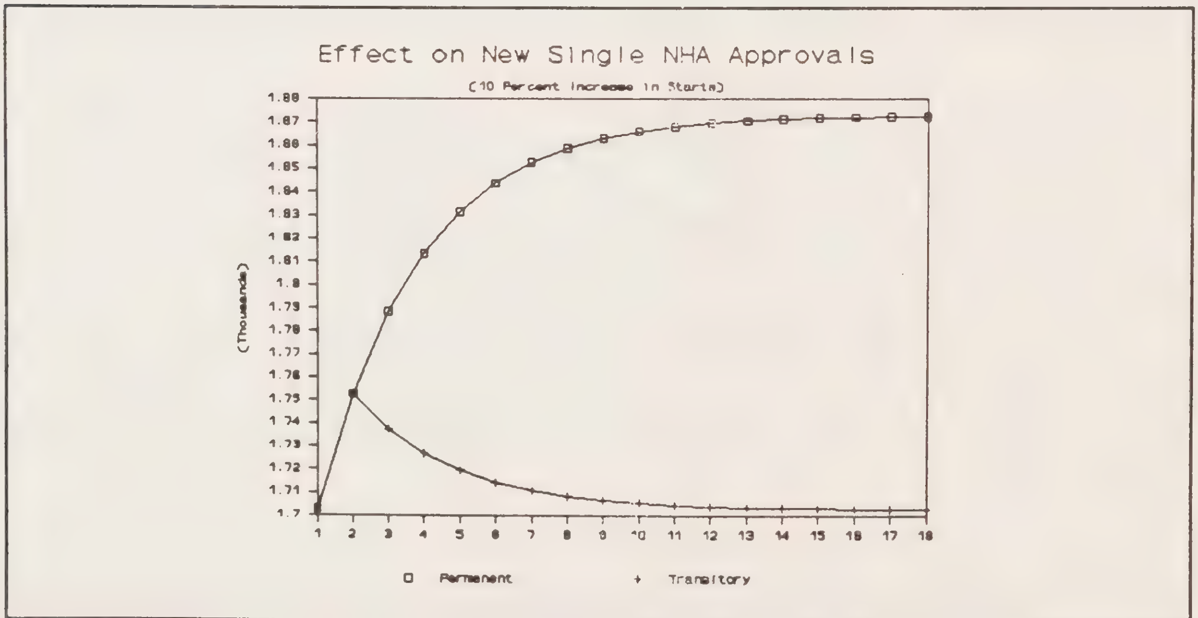


Figure 4.5

These graphs begin at the mean of the units approved and the mean for single housing starts. Housing starts are then increased by 10 percent in quarter 2 and the dynamics through the partial adjustment model are graphed.The faster response of conventional mortgage approvals compared with NHA approvals is clear in these graphs and follows immediately from the larger speed of adjustment coefficient for conventional approvals versus NHA approvals. (The speed of adjustment coefficients are 0.68 and 0.30 respectively.)

For conventional mortgage approvals, by the 7th quarter the adjustment is complete while for NHA mortgage approvals the adjustment takes over 12 quarters.

4.4.2 Mortgage Approvals for New Multiple Units

The specification for new multiple units approved follows that for single units approved. In particular, multiple units approved depend on multiple housing starts, the 5-year conventional mortgage rate and a time trend (or the population share aged 25-34) all in the context of a partial adjustment model. Perhaps what is most interesting in the results for new multiple dwelling units approved is that, in a statistical sense, the mortgage interest rate effects are non-existent for NHA units. Consequently, the final results presented here for NHA units approved do not include the mortgage rate. The results for multiples are set out in equations (4.19) and (4.20) for the period 1969, quarter 2 through 1990, quarter 4.

As in the case of single dwelling units approved, the time trend enters positively for conventional approvals and negatively for NHA approvals. This again reinforces the notion that over time there has been a movement towards conventional financing.

Also, following the specification for new singles approved, the long run elasticity of units approved with respect to new multiple starts is constrained to be one.

$$
\begin{aligned}
(4.19)\quad \log(MLANCONM) = & \underset{(3.89)}{-1.1418} + \underset{(2.48)}{0.2243*Q1} + \underset{(1.83)}{0.1530*Q2} \\
& - \underset{(0.66)}{0.0570*Q3} + \underset{(5.76)}{0.5102*\log(HSM)} - \underset{(1.89)}{0.0373*RMCON5YR} \\
& - \underset{(1.76)}{0.0200*D73*RMCON5YR} + \underset{(3.24)}{0.0055*TIME} \\
& + \underset{(5.53)}{0.4898*\log(MLANCONM(-1))}
\end{aligned}
$$

$\bar{R}^2 = 0.7480$ Mean of Dependent Variable = 7.5224
$h = -.257$ Std. Error of Regression = 0.2756

$$\text{(4.20)}\quad \log(\text{MLANNHAM}) = \underset{(0.17)}{-0.0374} - \underset{(5.51)}{1.0022}*\text{Q1} - \underset{(3.05)}{0.4902}*\text{Q2}$$

$$- \underset{(2.63)}{0.3978}*\text{Q3} + \underset{(5.41)}{0.6036}*\log(\text{HSM}) - \underset{(3.45)}{0.0096}*\text{TIME}$$

$$+ \underset{(3.55)}{0.3964}*\log(\text{MLANNHAM}(-1))$$

$\overline{R}^2 = 0.6734$ Mean of Dependent Variable = 8.0025
DW = 1.978   Std. Error of Regression = 0.4986

Table 4.2 sets out the elasticities of mortgage loan approvals of multiples with respect to starts and the 5-year conventional mortgage rate (where relevant). The elasticities with respect to the mortgage rate for conventional approvals are quite large in the long run indicating the important role of the market determined mortgage rate. Again, since this elasticity does vary through the sample, it is worthwhile to examine the time pattern of this elasticity. Figure 4.6 sets out this elasticity over the sample period. Once again, there are two important items to note from this figure; first, the elasticity does change substantially through the period - especially for the period 1980-1983 and, second, there is a clear difference between the period before 1973 and after 1973 (the point at which it is assumed the mortgage rate was truly market-determined).

Once again, it is worthwhile to consider the dynamics implied by these results through a consideration of the reaction of units approved to a 10 percent change in multiple housing starts. The relevant graphs are given in Figures 4.7 and 4.8. Of course, these dynamics are based on the speed of adjustment coefficients which, in this case, are 0.51 and 0.60 for conventional and NHA approvals respectively. For conventional mortgage approvals the adjustment in complete after 7 quarters, while for NHA approvals adjustment is complete after 5 quarters.

Finally, the difference between the new single dwellings and new multiple dwellings is quite important. Interestingly, the role of the mortgage rate is far more important (in terms of elasticities) for multiples than for singles (for conventional units approved). Furthermore, the mortgage rate only has a limited influence for NHA single units approved and no influence for NHA multiple units approved.

Table 4.2

Elasticities for Mortgage Loan Approvals for New Multiple Dwellings in Units

	Conventional Short Run	Conventional Long Run	NHA Short Run	NHA Long Run
With Respect to:				
Housing Starts	0.5102	1.0000	0.6036	1.0000
Mortgage Rate	-0.6915	-1.3553	--	--

<u>Notes</u>:

The elasticities on housing starts in the long run are constrained to be 1 and are constant through the sample in the short run. The elasticities with respect to the 5-year conventional mortgage rate are calculated at the sample means.

Source: based on the estimated coefficients presented in equations (4.19) and (4.20).

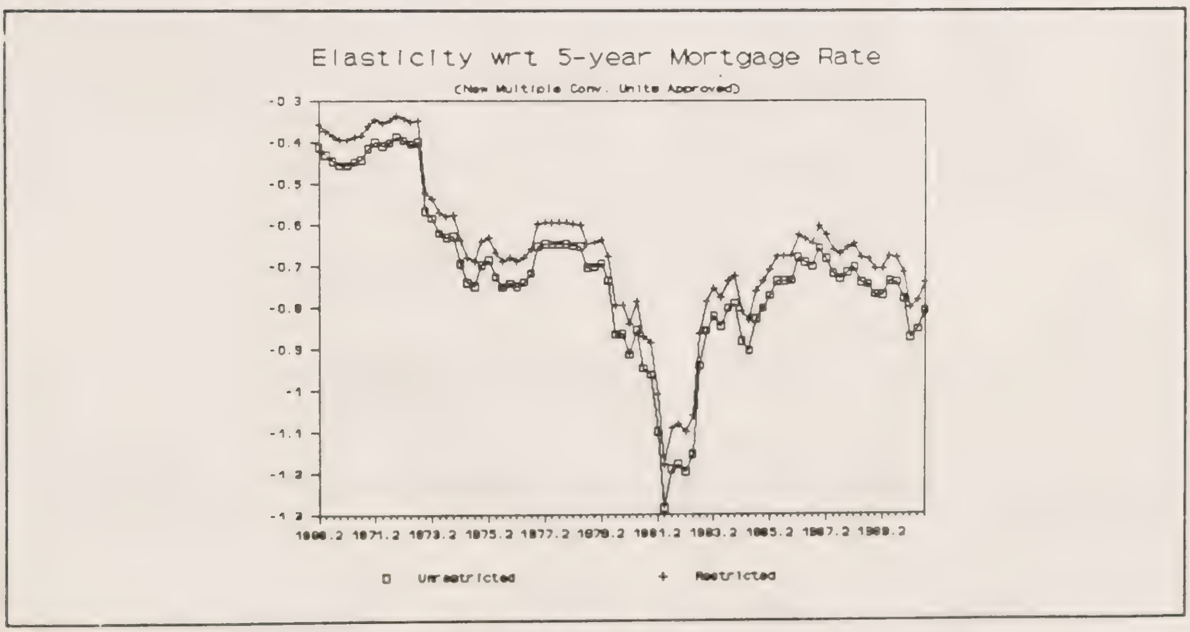


Figure 4.6

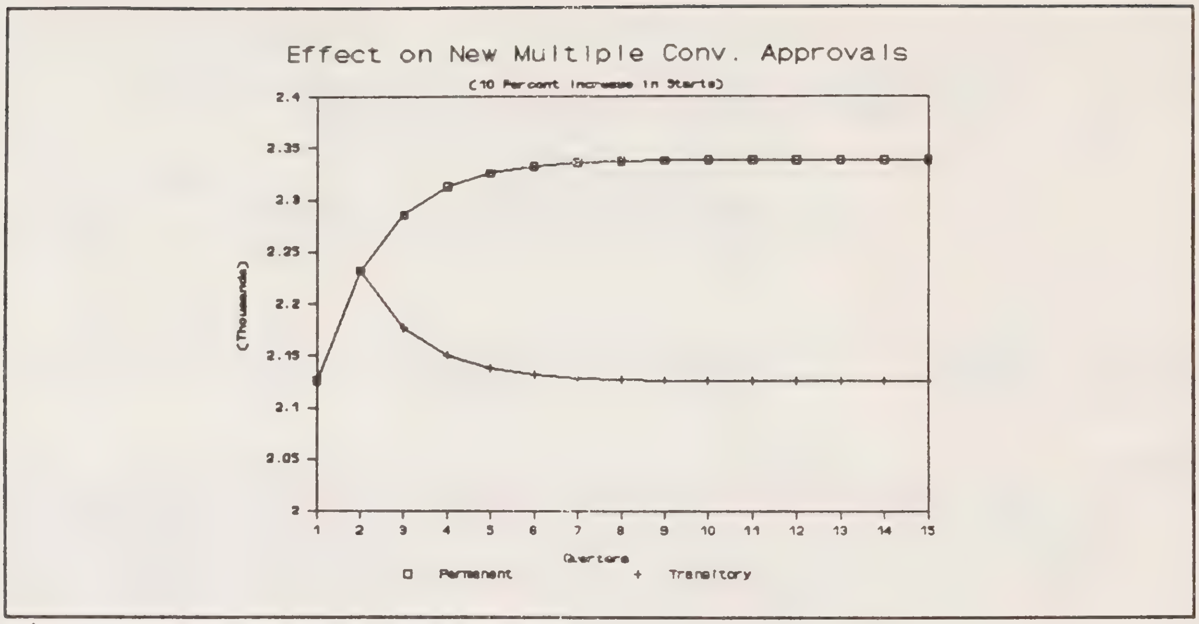


Figure 4.7

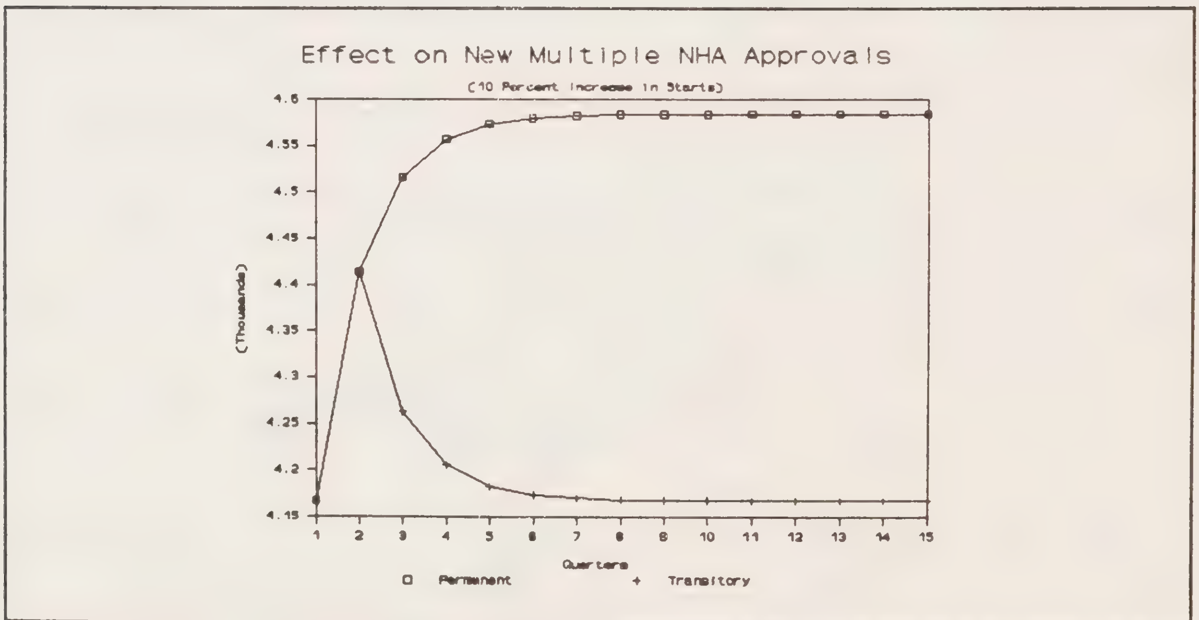


Figure 4.8

4.4.3 Mortgage Approvals for Existing Single Units

The specification for existing approvals, in essence, follows the same specification as for new units. However, there are two important changes. First, instead of housing starts, MLS sales (MLSS) are included in order to proxy the sales of existing units that must have mortgage approvals. In addition, the stock of available houses (KHS) is incorporated. Of course, not all of the stock must have their mortgage renewed, therefore the estimated coefficient on the stock is a combination of both the proportion of the stock that requires a mortgage renewal and the effect of the growth of the stock on the number of existing units approved. Second, the Canada Mortgage Renewal Plan (CMRP) was announced in November, 1981 and was designed to assist homeowners with financing problems on the renewal of mortgages between September, 1981 and November 12, 1982 (later extended to December 1983). Therefore, a dummy variable (DCMRP) which has the value 1 from 1981:4 through 1983:4 is introduced in the specification to account for this program. Also, as was the case for new units, in this specification the long run elasticity of approvals with respect to MLS sales is constrained to be one. However, we continue to assume that there is significant variation in the elasticity of approvals with respect to the mortgage rate over the sample period. Finally, since the MLS sales units begin in 1971:1 and end in 1990:3, the specification is estimated over this reduced period.

Equations (4.21) and (4.22) sets out the results for conventional and NHA mortgage approvals on existing units respectively.

$$
\begin{aligned}
(4.21)\quad \log(MLAECONS) = &- \underset{(6.63)}{11.9880} + \underset{(1.91)}{0.1161}*Q1 + \underset{(4.21)}{0.2506}*Q2 \\
&+ \underset{(1.16)}{0.0648}*Q3 + \underset{(6.89)}{1.5513}*\log(KHS) - \underset{(8.90)}{0.1197}*RMCON5YR \\
&+ \underset{(4.38)}{0.3243}*DCMRP + \underset{(9.64)}{0.6824}*\log(MLSS) \\
&+ \underset{(4.49)}{0.3176}*\log(MLAECONS(-1))
\end{aligned}
$$

$\overline{R}^2 = 0.9300$ Mean of Dependent Variable = 9.3305

$h = 4.05$ Std. Error of Regression = 0.1731

$$
\begin{aligned}
(4.22)\quad \log(MLAENHAS) = &- \underset{(3.31)}{6.2136} + \underset{(1.09)}{0.0746}*Q1 + \underset{(4.84)}{0.3428}*Q2 \\
&+ \underset{(0.61)}{0.0395}*Q3 + \underset{(3.33)}{0.7562}*\log(KHS) - \underset{(5.92)}{0.0815}*RMCON5YR
\end{aligned}
$$

$$+ 0.3257*DCMRP + 0.4814*\log(MLSS)$$
$$(3.82) \qquad (6.67)$$

$$+ 0.5186*\log(MLAENHAS(-1))$$
$$(7.18)$$

$\overline{R}^2 = 0.8925$ Mean of Dependent Variable = 8.2151
h = 2.32 Std. Error of Regression = 0.1997

A time trend was not included in these specifications since it was highly collinear with the stock variable. Note that in both cases the dummy variable for the assistance program (CMRP) enters the regressions positively and significantly as expected. The mortgage rate variable enters negatively and is very significant in these equations (because the sample period begins in 1971, the interaction term between the mortgage rate and the dummy variable which begins in 1973 is not included). Finally, the speed of adjustment coefficients for existing single units implied by the partial adjustment specification adopted here are 0.68 and 0.48 for conventional mortgage approvals and NHA approvals respectively.

Table 4.3 sets out the elasticities of single dwelling mortgage approvals with respect to the housing stock and mortgage rates. We see that the results are very similar in terms of these elasticities. The elasticities on MLS sales indicate that in the short run, a one percent change in these sales results in a 0.68 percent increase in units approved for conventional mortgages and a 0.48 percent increase in units approved for NHA mortgages. In the long run these elasticities are constrained to be equal to one. While the elasticities on housing stocks are large, it is important to remember that the average annual growth rate of the single dwelling stock over the entire period 1969-1990 was only 2.2 percent. The influence of the mortgage rate is strong for existing single units approved for both conventional and NHA approvals.

It is useful to consider the dynamics in these results, as introduced through the partial adjustment model. In this case, the mortgage rate is increased by 10 percent over its mean value in the sample (from 12.06 to 13.26 percent) in quarter 2 and the effect on approved units is traced by quarter beginning at its mean value. These dynamic effects are set out in Figure 4.9. Note that the dynamics in both the case of conventional and NHA approvals are completed by the eighth quarter.

Table 4.3

Elasticities for Mortgage Loan Approvals for Existing Single Dwellings in Units

With Respect to:	Conventional Short Run	Conventional Long Run	NHA Short Run	NHA Long Run
MLS Sales	0.6824	1.0000	0.4814	1.0000
Housing Stock	1.5513	2.2734	0.7562	1.5709
Mortgage Rate	-1.4662	-2.1486	-0.9979	-2.0729

Notes:
The elasticities with respect to MLS sales in the long run is constrained to be 1 and the elasticities with respect to MLS sales and the housing stock are constant through the sample in the short run. The elasticities with respect to the 5-year conventional mortgage rate are calculated at the sample mean (12.248 percent).

Source: based on the estimated coefficients presented in equations (4.21) and (4.22).

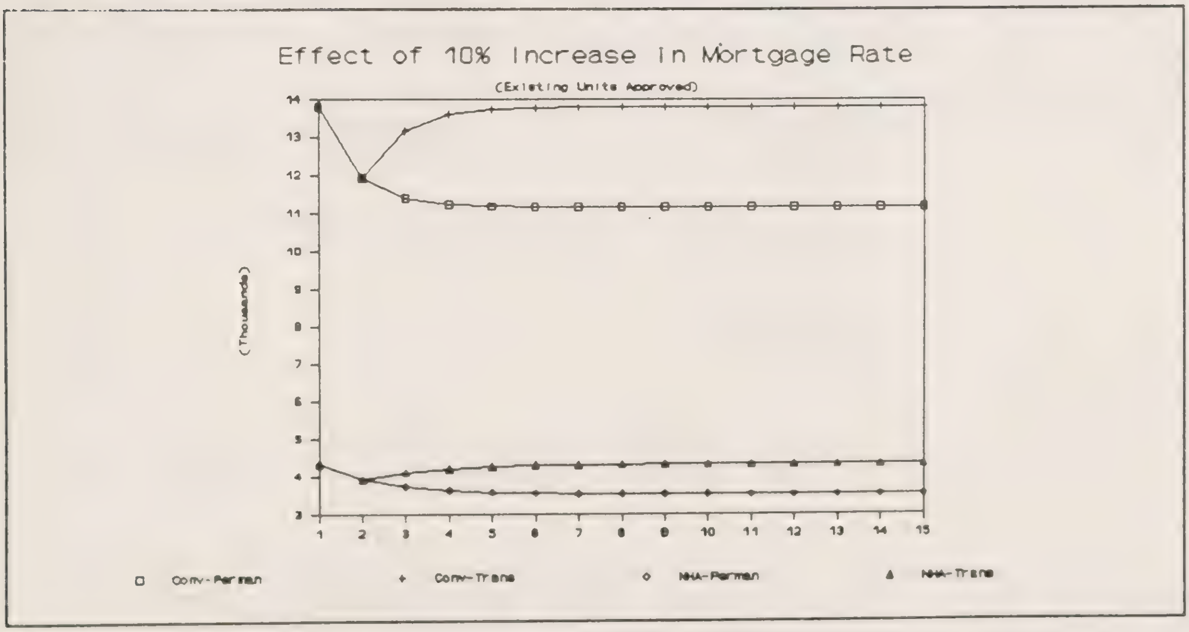


Figure 4.9

4.4.4 Mortgage Approvals for Existing Multiple Units

The specification for existing multiple unit approvals is a function of the stock of multiple dwellings, the 5-year conventional mortgage rate and the dummy variable for the program designed to assist homeowners re-finance their mortgages. Again, these results, set out in equations (4.23) and (4.24), are robust to specification.

$$
\begin{aligned}
(4.23)\quad \log(\text{MLAECONM}) = & \underset{(4.67)}{-10.4678} + \underset{(1.27)}{0.0895*\text{Q1}} + \underset{(0.96)}{0.0660*\text{Q2}} \\
& - \underset{(2.46)}{0.1740*\text{Q3}} + \underset{(4.91)}{1.4087*\log(\text{KHM})} - \underset{(6.91)}{0.1225*\text{RMCON5YR}} \\
& + \underset{(6.69)}{0.5651*\log(\text{MLSS})} + \underset{(5.65)}{0.5281*\text{DCMRP}} \\
& + \underset{(5.15)}{0.4349*\log(\text{MLAECONM}(-1))} + \underset{(2.19)}{0.5384*\text{D803}}
\end{aligned}
$$

$\bar{R}^2 = 0.9052$ Mean of Dependent Variable = 8.8427
h = 3.19 Std. Error of Regression = 0.2138

$$
\begin{aligned}
(4.24)\quad \log(\text{MLAENHAM}) = & \underset{(2.27)}{-7.0548} - \underset{(3.75)}{0.3189*\text{Q1}} - \underset{(0.51)}{0.0445*\text{Q2}} \\
& - \underset{(4.53)}{0.3847*\text{Q3}} + \underset{(2.15)}{0.7868*\log(\text{KHM})} - \underset{(2.11)}{0.0495*\text{RMCON5YR}} \\
& + \underset{(2.42)}{0.0383*\text{D73}*\text{RMCON5YR}} + \underset{(4.95)}{0.4098*\log(\text{MLSS})} \\
& + \underset{(2.70)}{0.3042*\text{DCMRP}} + \underset{(7.12)}{0.5902*\log(\text{MLAENHAM}(-1))} \\
& + \underset{(3.08)}{0.8274*\text{D803}}
\end{aligned}
$$

$\bar{R}^2 = 0.9229$ Mean of Dependent Variable = 7.2298
h = -2.09 Std. Error of Regression = 0.2606

In these equations, both the stock variable (KHM) and MLS sales of existing units (MLSS) enter with the expected signs and are significant. The mortgage rate also enters significantly but, as noted below, the impact on units approved is quite different. The effect of the mortgage assistance program (DCMRP) is significant

and increases units approved in both equations. Finally, note that in both equations, a dummy variable is added for the third quarter of 1980.

Table 4.4 sets out the elasticities of existing multiple units approved with respect to MLS sales, the stock of multiple units and the mortgage rate. In this case, the elasticities with respect to the MLS sales is not very different between conventional and NHA approvals. Furthermore, as described earlier, these elasticities are constrained to be one in the long run. This implies that, in the long run, the entire percent increase in MLS sales is reflected by the same percent increase in units approved. The elasticity of units approved with respect to the housing stock are quite large, although as with singles, the growth of the stock is quite slow over the sample period. The elasticities with respect to the mortgage rate are quite different between conventional and NHA units approved. This may reflect the different types of dwellings financed by conventional versus NHA mortgages and, in particular, the role of social assisted housing approved through the NHA.

The speed of adjustment coefficients are not substantially different -- 0.57 for conventional approvals and 0.41 for NHA approvals. Therefore, the response of units approved to a change in a variable will exhibit a similar time pattern, although the magnitude of the impact as a result of the changes in the variables will be different.

In the case of existing singles and multiples, the long run elasticity with respect to existing MLS sales is constrained to be one. Once again, this implies something about the change in the share of loans approved out of MLS sales. In particular, in the long run, this share is a function of the seasonal dummies, the respective stocks of singles and multiples, the mortgage rate and, where appropriate the Mortgage Renewal Plan.

Table 4.4

Elasticities for Mortgage Loan Approvals for Existing Multiple Dwellings in Units

	Conventional		NHA	
	Short Run	Long Run	Short Run	Long Run
With Respect to:				
MLS Sales	0.5651	1.0000	0.4098	1.0000
Housing Stock	1.4087	2.4927	0.7868	1.2000
Mortgage Rate	-1.5000	-2.6545	-0.1362	-0.3325

Notes:
The elasticities with respect to MLS sales in the long run is constrained to be 1 and the elasticities with respect to MLS sales and the housing stock are constant through the sample in the short run. The elasticities with respect to the 5-year conventional mortgage rate are calculated at the sample mean (12.248 percent).

Source: based on the estimated coefficients presented in equations (4.23) and (4.24).

4.5 Results for the Average Loan per Unit

In this section, we explore the relationship between the average mortgage loan per unit for new single and multiple dwellings for conventional and NHA mortgage approvals and the new house price index (NHPI) and the conventional mortgage rate. In addition, regressions are undertaken for the average loan per unit on existing dwellings, both for conventional and NHA approvals. In this case the explanatory variables are the conventional mortgage rate and the MLS price on resale units (MLSP). The dependent variable is defined as total mortgage approvals (in dollars) for the relevant category divided by the total number of units approved in that category. Therefore, the dependent variables is the average loan per unit approved. For new dwellings the sample period is 1971:2 through 1990:4 while for existing dwellings the sample is restricted to 1977:1 through 1990:4 (due to the unavailability of the MLS price before 1977).

In this case, after preliminary examination, it turned out that both the elasticity of the average loan with respect to the new house price index and the mortgage rate varied through the sample. That is, in this case the specification is not estimated in terms of a partial logarithmic specification. Furthermore, it also

appears unreasonable to constrain the long run elasticity of the average loan with respect to the new house price index to one (based on the empirical results).

Before turning to the results, consider the sign expectations. The house price index should enter positively since as the price of houses (whether new or existing) rises, the average loan that a home buyer must take out should also rise. As the mortgage rate rises, it is likely that home buyers will try to make a larger down-payment and therefore require a lower mortgage loan. In all cases a partial adjustment model is used to introduce dynamics into the process.

4.5.1 New Single Dwellings

For new single dwelling units, the regressions for the average loan performed very well for both conventional and NHA mortgage approvals and these are set out in equations (4.25) and (4.26). The new house price index enters positively and the 5-year conventional mortgage rate enters negatively as expected. There are a few data points that seem odd and, therefore, dummy variables are entered for certain quarters in these specifications (the plots in Appendix 4C identify these data points).

$$(4.25) \quad \mathrm{ALNCONS} = \underset{(2.13)}{3635.43} + \underset{(1.19)}{855.53*\mathrm{Q1}} - \underset{(2.25)}{1611.33*\mathrm{Q2}}$$

$$- \underset{(1.80)}{1260.63*\mathrm{Q3}} + \underset{(1.25)}{69.527*\mathrm{NHPI}} - \underset{(3.00)}{334.380*\mathrm{RMCON5YR}}$$

$$+ \underset{(15.01)}{0.9363*\mathrm{ALNCONS(-1)}} + \underset{(3.92)}{9156.159*\mathrm{D891}}$$

$$- \underset{(4.69)}{11148.663*\mathrm{D892}}$$

$\bar{R}^2 = 0.9926$ Mean of Dependent Variable = 61847.92

$h = -.006$ Std. Error of Regression = 2213.876

$$(4.26) \quad \mathrm{ALNNHAS} = - \underset{(0.19)}{256.01} + \underset{(3.67)}{2518.39*\mathrm{Q1}} + \underset{(0.14)}{88.43*\mathrm{Q2}} + 675.03*\mathrm{Q3}$$

$$+ \underset{(2.23)}{72.448*\mathrm{NHPI}} - \underset{(1.58)}{163.108*\mathrm{RMCON5YR}}$$

$$+ \underset{(23.16)}{0.9243*\mathrm{ALNNHAS(-1)}} - \underset{(2.79)}{5879.71*\mathrm{D794}} + \underset{(3.21)}{6790.11*\mathrm{D801}}$$

$$+ \underset{(3.80)}{8055.14*\mathrm{D841}}$$

$\bar{R}^2 = 0.9924$ Mean of Dependent Variable = 52803.77
h = -1.47 Std. Error of Regression = 2041.38

Table 4.5 sets out the elasticities of the average loan approved for new single dwellings with respect to the new housing price index and the 5-year mortgage rate. For conventional approvals, the short run elasticity of the average loan with respect to the NHPI is 0.09 (hence a one percent increase in the new house price index results in a 0.09 percent increase in the average loan in the current quarter). In the long run, however, this elasticity increases to 1.48. The elasticity with respect to the mortgage rate is also small in the short run (at -0.06), but rises to -1 percent in the long run. The effect on the average loan for NHA mortgages are similar for the new house price index, but the elasticities with respect to the mortgage rate are smaller. In this case, this may reflect partly a financing choice. Since NHA borrowers normally use high financing ratios, if they increase their down-payment significantly in response to high mortgage rates, then they become conventional borrowers. Consequently, the smaller elasticity of the average loan with respect to the mortgage rate for NHA loans may reflect a choice to move to conventional borrowing. The time path of adjustment from the short run to the long run is quite similar in this case since the speed of adjustment coefficients are similar, although small (0.064 and 0.076 for conventional and NHA average loans respectively).

An alternative way to examine these elasticities, which vary through the sample, is through an examination of the time pattern of the elasticities. These are set out for the new house price index and the mortgage rate in Figures 4.10 and 4.11 respectively. Interestingly, the response of the elasticities is similar for conventional and NHA average loans. In particular, the elasticity with respect to the new house price index declines through the sample period, although after 1983 this elasticity seems to have slowed (or possibly ended) its decline. The elasticities with respect to the mortgage rate also decline in absolute value although, again, the elasticity seems to become more stable near the end of the sample period (from approximately 1986 on).

It is also useful to consider the dynamics of the average loan to a change in its determinants as given by these equations. Since the speed of adjustment coefficient is similar for conventional versus NHA mortgage average loans, we focus only on conventional loans here. Figure 4.12 sets out the impact of a permanent and transitory 10 percent increase in the new house price index from its mean value (beginning from the mean loan for new single conventional loans). As this figure shows, it takes over 24 quarters for the increase in the price to be completely reflected in the average loan.

Table 4.5

Elasticities for Average Loan Approved for
New Single Dwellings

With Respect to:	Conventional Short Run	Conventional Long Run	NHA Short Run	NHA Long Run
New House Price	0.0946	1.4841	0.1187	1.5678
Mortgage Rate	-0.0644	-1.0102	-0.0378	-0.4995

Notes:
The elasticities are calculated at the sample means.

Source: based on the estimated coefficients presented in equations (4.25) and (4.26).

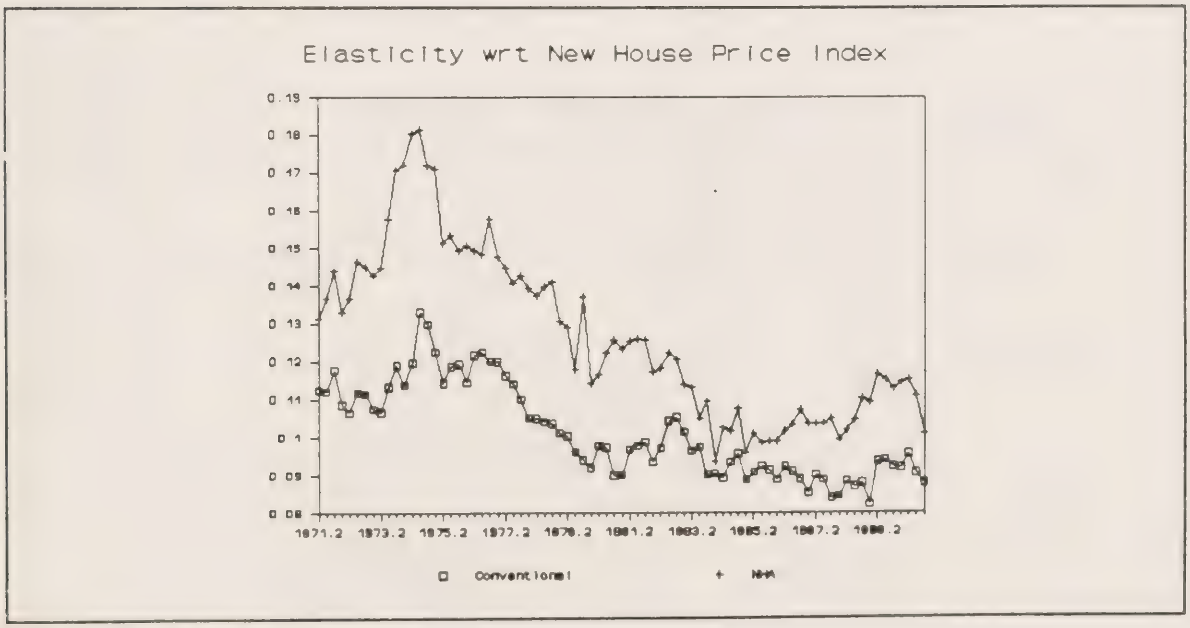


Figure 4.10

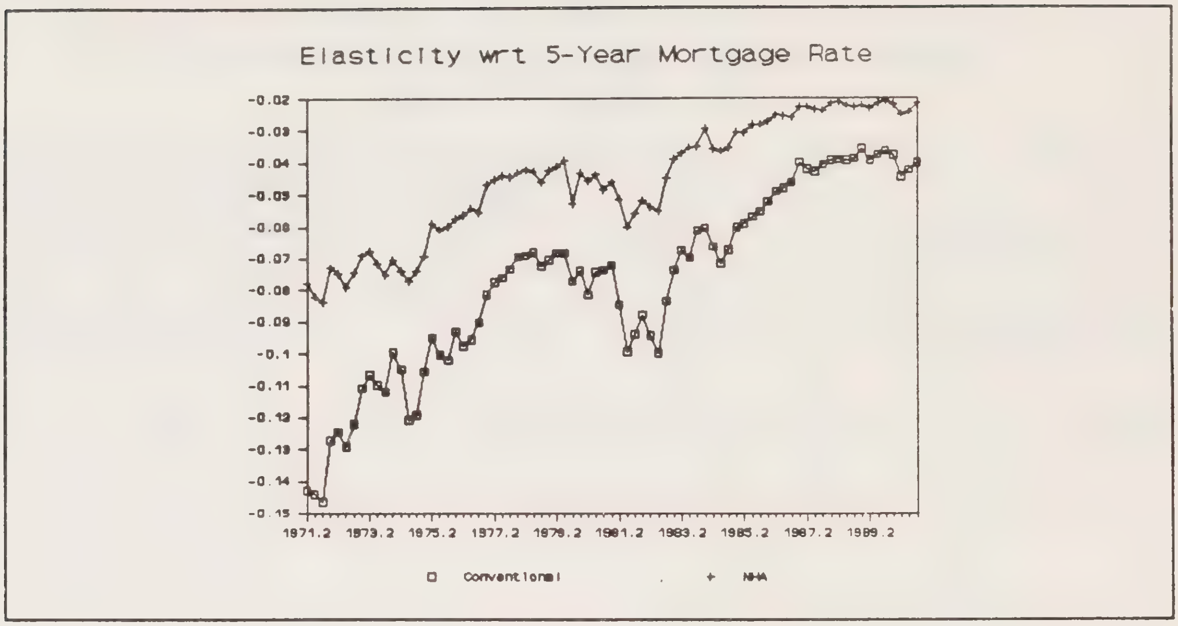


Figure 4.11

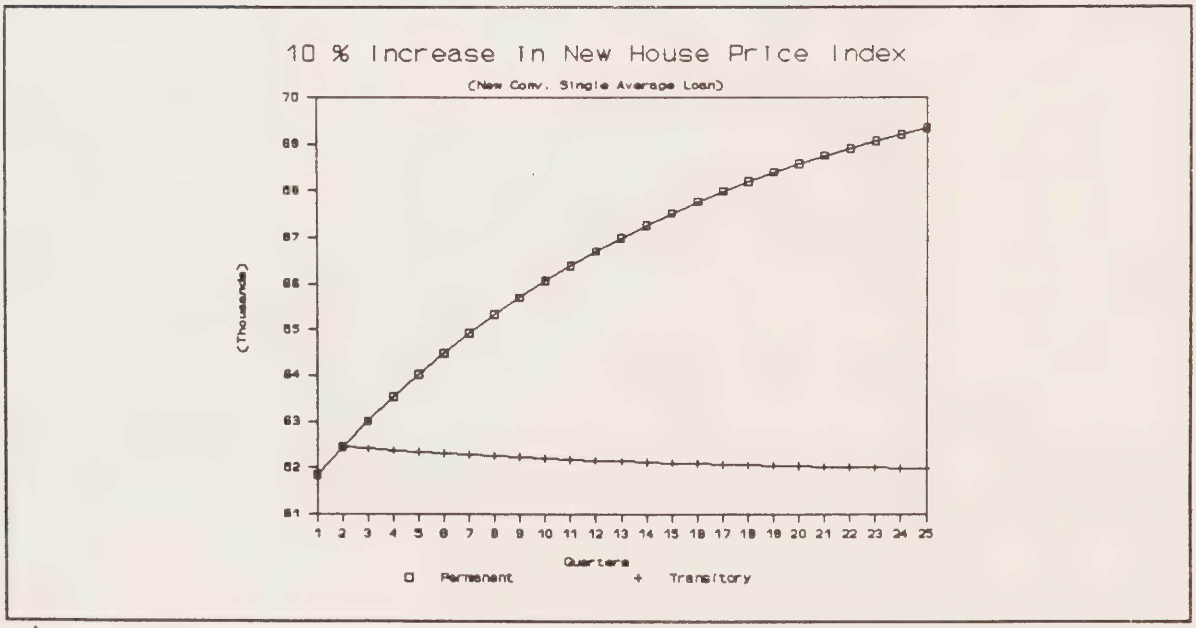


Figure 4.12

4.5.2 New Multiple Dwellings

The next set of results are for the average loan for new multiple approvals. Again, the basic specification uses, as explanatory variables, the new house price index and the five year mortgage rate. A partial adjustment model is used in the specification which leads to the inclusion of a lagged dependent variable. In addition, there seem to be some strange data points and, so that the other parameter estimates are not significantly affected, dummy variables are incorporated into the specification for some quarters, where appropriate. The results are set out in equations (4.27) and (4.28).

$$
\begin{aligned}
(4.27)\quad ALNCONM = & \underset{(3.40)}{-12548.61} - \underset{(0.23)}{412.72*Q1} + \underset{(1.50)}{2675.55*Q2} \\
& + \underset{(0.87)}{1506.52*Q3} + \underset{(8.26)}{580.63*NHPI} - \underset{(2.18)}{599.68*RMCON5YR} \\
& + \underset{(1.64)}{0.1666*ALNCONM(-1)} - \underset{(2.93)}{16360.05*D832} \\
& - \underset{(4.91)}{28335.05*D894}
\end{aligned}
$$

$\bar{R}^2 = 0.9231$ Mean of Dependent Variable = 36750.91
h = 1.91 Std. Error of Regression = 5419.54

$$
\begin{aligned}
(4.28)\quad ALNNHAM = & \underset{(2.44)}{-6610.73} - \underset{(0.24)}{317.80*Q1} + \underset{(0.34)}{437.90*Q2} \\
& + \underset{(1.44)}{1799.93*Q3} + \underset{(5.84)}{405.53*NHPI} - \underset{(1.92)}{398.86*RMCON5YR} \\
& + \underset{(5.69)}{0.4816*ALNNHAM(-1)} - \underset{(6.57)}{27133.51*D881} \\
& + \underset{(7.38)}{35135.47*D882}
\end{aligned}
$$

$\bar{R}^2 = 0.9700$ Mean of Dependent Variable = 45858.05
h = 0.31 Std. Error of Regression = 3951.14

Table 4.6 sets out the elasticities of the average loan for new multiple units with respect to the new house price index and the mortgage rate. While there is considerable difference in the

Table 4.6

Elasticities for Average Loan Approved for New Multiple Dwellings

	Conventional Short Run	Conventional Long Run	NHA Short Run	NHA Long Run
With Respect to:				
New House Price	1.3673	1.6407	0.7653	1.4763
Mortgage Rate	-0.1999	-0.2398	-0.1065	-0.2055

<u>Notes</u>:
The elasticities are calculated at the sample means.

Source: based on the estimated coefficients presented in equations (4.27) and (4.28).

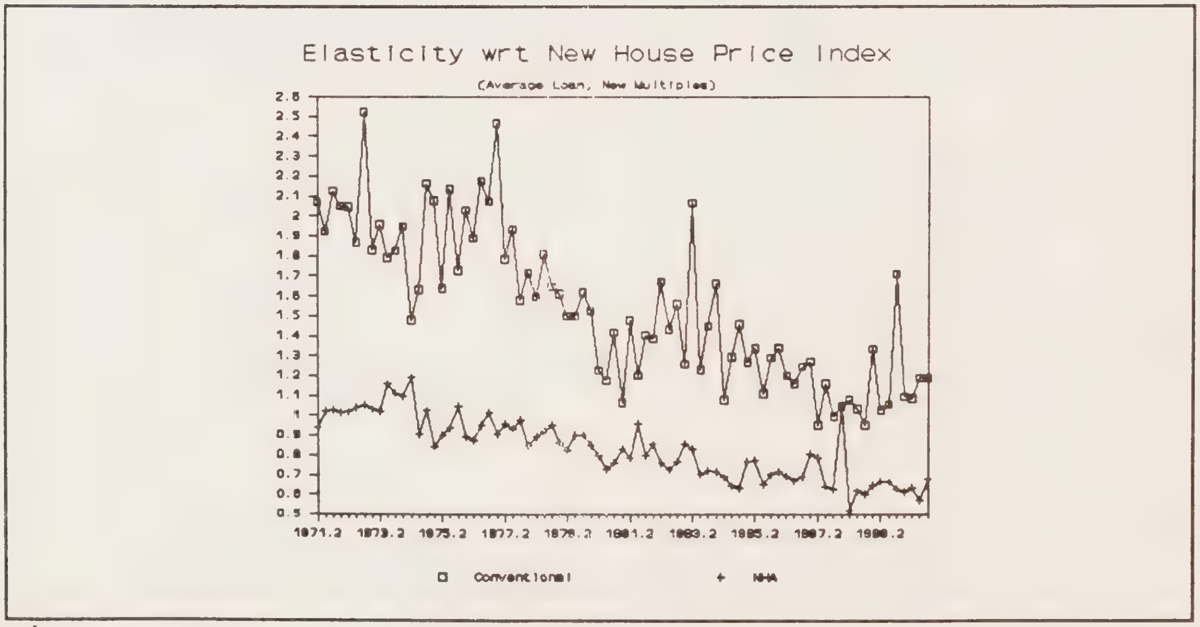


Figure 4.13

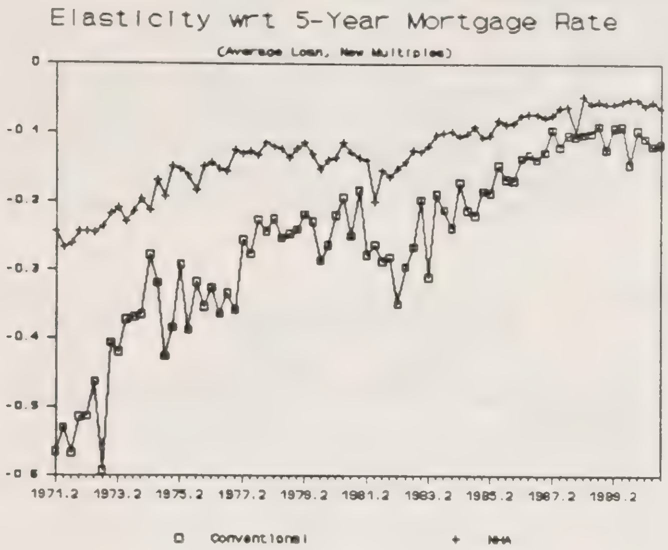


Figure 4.14

short run elasticities for conventional versus NHA average loans with respect to the new house price index, the long run elasticities are quite similar. This is a reflection of the difference in the speed of adjustment coefficients. In this case, the speed of adjustment is much faster for the average loan on conventional versus NHA approvals. Also interesting is that, in this case, the long run elasticities with respect to the mortgage rate are also similar.

However, these elasticities are computed at the sample means and, by design, the specification allows the elasticities to vary through the sample. In order to examine the time pattern of these elasticities through the sample, Figures 4.13 and 4.14 sets out the elasticities with respect to the new house price index and the mortgage rate respectively. Again, we observe the same general trends in these elasticities as was the case with the average loan for new single dwellings; that is, the absolute value of the elasticity declines both with respect to the new house price index and with respect to the mortgage rate. Note that at the end of the sample period the elasticity with respect to the new house price index is approximately one while the elasticity with respect to the mortgage rate is roughly -0.1.

4.5.3 Existing Single Dwellings

For average loan per unit on existing single dwelling units, the regressions follow that for new housing with the new house price

index replaced by the MLS price (MLSP) to account for the movements in the price of resales. The major change in these results is that once again it appears reasonable to assume that the elasticity of the average loan per unit with respect to the MLS house price is constant and, in the long run, the elasticity is equal to one. However, the elasticity with respect to the mortgage rate is assumed to vary through the sample period. The results are set out in equations (4.29) and (4.30). The MLS price enters positively and the 5-year conventional mortgage rate enters negatively as expected.

$$
\begin{aligned}
(4.29)\quad \log(ALECONS) = \; & \underset{(1.16)}{0.0464} - \underset{(0.33)}{0.0040*Q1} - \underset{(1.33)}{0.0152*Q2} - \underset{(1.51)}{0.0174*Q3} \\
& + \underset{(1.38)}{0.0993*\log(MLSP)} - \underset{(2.13)}{0.0035*RMCON5YR} \\
& + \underset{(12.5)}{0.9007*\log(ALECONS(-1))} - \underset{(1.42)}{0.0004*TIME} \\
& + \underset{(4.29)}{0.1384*D871} - \underset{(3.01)}{0.0961*D881}
\end{aligned}
$$

$\bar{R}^2 = 0.9912$ Mean of Dependent Variable = 10.9372
$h = -.36$ Std. Error of Regression = 0.0300

$$
\begin{aligned}
(4.30)\quad \log(ALENHAS) = \; & \underset{(1.36)}{0.0381} - \underset{(0.18)}{0.0020*Q1} - \underset{(2.35)}{0.0259*Q2} + \underset{(0.49)}{0.0054*Q3} \\
& + \underset{(2.38)}{0.1418*\log(MLSP)} - \underset{(3.02)}{0.0055*RMCON5YR} \\
& + \underset{(14.4)}{0.8582*\log(ALENHAS(-1))} - \underset{(1.36)}{0.0005*TIME}
\end{aligned}
$$

$\bar{R}^2 = 0.9872$ Mean of Dependent Variable = 10.8197
$h = 2.29$ Std. Error of Regression = 0.0291

Once again, the interesting results are found through a comparison of elasticities and speed of adjustment coefficients. First, with regard to the speed of adjustment coefficients, these are quite similar (0.10 for conventional singles and 0.14 for NHA singles) and quite slow. This suggests that adjustment from the short run to the long run will be quite similar in both cases.

The implied short run and long run elasticities are set out in Table 4.7, Panel A. The elasticity with respect to the MLS price

is quite small in the short run and is constrained to be equal to one in the long run. The elasticity on the mortgage rate varies through the sample period and, as Table 4.7 indicates, in the long run this elasticity is very close to -0.5. Since this elasticity does vary through the sample it is useful to consider its time pattern. This is displayed in Figure 4.15. Once again we observe that indeed the elasticity varies significantly -- especially over the period where mortgage interest rates varied so much (between 1980 and 1983).

4.5.4 Existing Multiple Dwellings

For existing multiple dwelling units, the regressions for the average loan follow that for single multiple housing and the results are set out in equations (4.31) and (4.32). This specification again adopts a constant elasticity of the average loan per unit with respect to the MLS price and, in the long run, this elasticity is constrained to be one. In addition, the elasticity with respect to the mortgage rate is allowed to vary through the sample. Again, the MLS price enters positively and the 5-year conventional mortgage rate enters negatively as expected.

Table 4.7

Elasticities for Average Loan Approved for Existing Dwellings

A. Singles

	Conventional		NHA	
	Short Run	Long Run	Short Run	Long Run
With Respect to:				
MLS Price	0.0993	1.0000	0.1418	1.0000
Mortgage Rate	-0.0460	-0.4627	-0.0715	-0.5040

B. Multiples

	Conventional		NHA	
	Short Run	Long Run	Short Run	Long Run
With Respect to:				
MLS Price	0.4453	1.0000	0.3514	1.0000
Mortgage Rate	-0.0835	-0.1876	-0.2351	-0.6692

Notes:
The elasticities with respect to the mortgage rate are calculated at the sample mean.

Source: based on the estimated coefficients presented in equations (4.29) through (4.32) respectively.

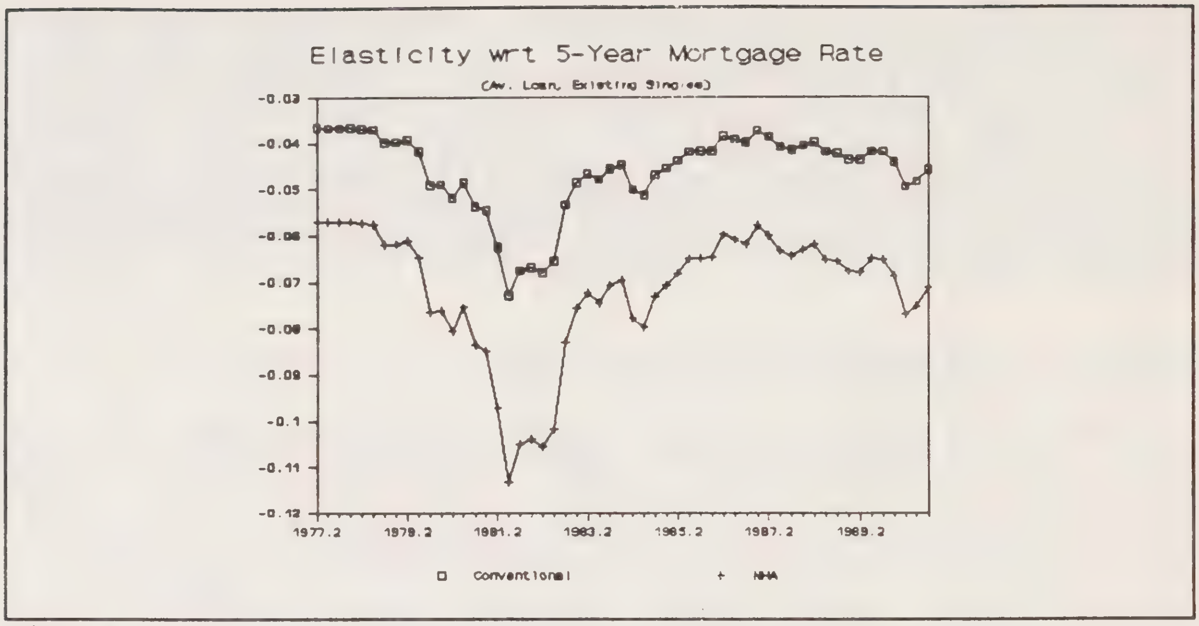


Figure 4.15

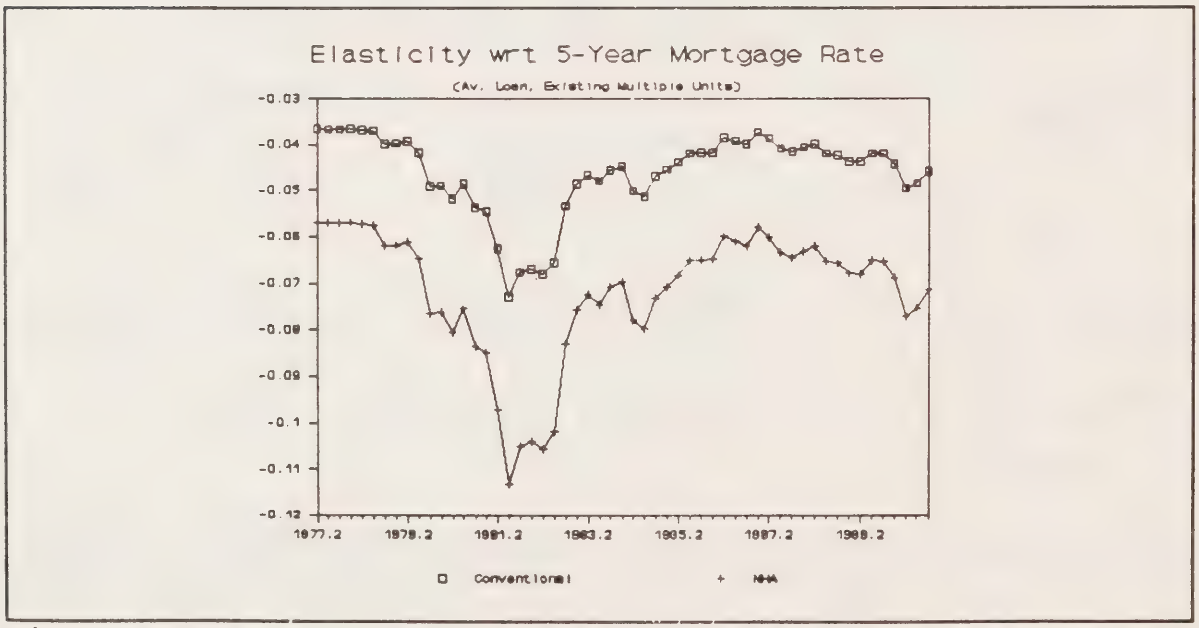


Figure 4.16

$$
(4.31)\quad \log(ALECONM) = -\underset{(2.91)}{0.6692} - \underset{(0.41)}{0.0130}*Q1 + \underset{(2.11)}{0.0664}*Q2 \qquad (0.80)
$$

$$
+ \underset{(0.80)}{0.0251}*Q3 + \underset{(3.52)}{0.4453}*\log(MLSP) - \underset{(1.43)}{0.0064}*RMCON5YR
$$

$$
+ \underset{(4.38)}{0.5547}*\log(ALECONM(-1)) + \underset{(2.58)}{0.0029}*TIME
$$

$\bar{R}^2 = 0.9649$ Mean of Dependent Variable = 10.0278
DW = 1.977 Std. Error of Regression = 0.0820

$$
(4.32)\quad \log(ALENHAM) = -\underset{(1.11)}{0.0963} + \underset{(0.20)}{0.0088}*Q1 + \underset{(1.27)}{0.0535}*Q2
$$

$$
+ \underset{(1.57)}{0.0657}*Q3 + \underset{(3.58)}{0.3514}*\log(MLSP) - \underset{(2.36)}{0.0181}*RMCON5YR
$$

$$
+ \underset{(6.61)}{0.6486}*\log(ALENHAM(-1))
$$

$\bar{R}^2 = 0.8766$ Mean of Dependent Variable = 10.4928
h = -4.13 Std. Error of Regression = 0.1108

For multiples, the speed of adjustment coefficients are larger than for singles (0.45 for conventional approvals and 0.35 for NHA approvals) implying that the adjustment to a change in prices or mortgage rates happens much faster for multiple average loans per unit. The relevant short run and long run elasticities are set out in Table 4.7, Panel B. In comparing the elasticities between singles and multiples, we note that the short run elasticity with respect to the MLS price is larger for multiples than singles while, in the long run at least, there is not too great a difference in the elasticities with respect to the mortgage rate (of course, there is no difference in the long run elasticities with respect to the MLS price by assumption).

Again since the elasticity with respect to the mortgage rate varies through the sample, Figure 4.16 sets out the time pattern of this elasticity through the sample period. Again, it is interesting to note the fluctuation in this elasticity during the high interest rate period of the early 1980s.

4.6 Regression Results for Mortgage Rates

In this section results for the determination of the mortgage rate are presented. First, the sample period for the 5-year chartered bank typical and 5-year conventional mortgage rates is restricted

to be from 1973:2 through 1990:4. Beginning in 1973 helps avoid the problems related to the freeing of the mortgage rate which began in 1969. However, as the data in Figure 4.1 indicate, while there can be little doubt that there is a strong relationship between the 5-year conventional mortgage rate and the 3-5 year Government of Canada bond rate, the period from 1973 to the end of 1976 seems to be different from the subsequent period. Furthermore, from 1984 through the end of 1990, the relationship between these rates seems to exhibit a reduced variance. Consequently, dummy variables are added to the specification to account for these obvious structural changes as well as dummy variables for the quarters in 1980 to reflect adjustments as a result of the move to a floating bank rate.

The 1 and 3 year mortgage rates are estimated over the period 1980:2 through 1990:4 since the data for these rates begin in 1980. The regression results for these rates are set out in Table 4.8.

In the case of the 1-year, 3-year and 5-year mortgage rate, using the treasury bill rate as an explanatory variable produced the best results. The 5-year conventional mortgage rate is related to the 3-5 year Government of Canada bond rates. There are also a series of dummy variables added: the first set is for the events in 1980 when the Bank of Canada allowed the Bank Rate to float. The second is for the period from 1984 on, where, as evidenced through Figure 4.1, there is a substantial reduction of the variance of the

Table 4.8

Regression Results for Mortgage Rates

	1-Year Rate	3-Year Rate	5-Year Rate	Conventional 5-Year Rate
Constant	0.0715	1.6568	1.5661	0.1284
	(0.18)	(1.83)	(3.67)	(0.45)
Q1	0.2273	0.2591	-0.0045	-0.1102
	(1.00)	(0.93)	(0.02)	(0.95)
Q2	0.4421	0.5707	0.2934	-0.0203
	(1.98)	(2.03)	(1.42)	(0.17)
Q3	0.5131	0.5935	0.3188	-0.0219
	(2.33)	(2.19)	(1.55)	(0.19)
RTB	0.5799	0.4415	0.3579	--
	(13.05)	(8.95)	(9.28)	
RGOC35	--	--	--	0.7000
				(18.87)
Lagged Dependent Variable	0.4486	0.4997	0.5877	0.4187
	(9.99)	(7.41)	(12.74)	(13.02)
Dummy 1980:1	--	--	--	-1.2236
				(3.41)
Dummy 1980:2	--	-0.5842	--	0.9902
		(1.91)		(2.82)
Dummy 1980:3	--	--	--	-1.1372
				(3.24)
Dummy 1984:1 ON	--	-0.8927	-0.3782	-0.2356
		(1.32)	(2.47)	(2.43)
Dummy 1973:2-1976:4	--	--	--	0.9251
				(6.90)
$\overline{R}^2$	0.9683	0.9467	0.9375	0.9800
Durbin's h	-1.73	-1.99	-1.61	-1.77
Mean of Dep. Var.	12.626	13.269	12.617	12.586
Std. Err. of Regress.	0.509	0.627	0.615	0.336

differential between the Government of Canada bond rate and the 5-year conventional mortgage rate. The third set is for the period 1973:2 through 1976:4 as a result of obvious differences in the structural relationship between the 5-year conventional rate and the 3-5 year bond rate. In all cases, a partial adjustment model was adopted.

As these results indicate, the interest rates enter positively and significantly as expected. The dummy variables are also significant and, in particular, for the 5-year conventional mortgage rate the dummy variable for the period from 1984-1990 is negative, in effect showing a reduced differential with the Government of Canada bond rate than before 1984. Secondly, the dummy variable for the period 1973-76 in also significant and positive indicating a greater spread over the 3-5 year bond rate of almost 1 percentage point.

Finally, Table 4.9 sets out the short run and long run elasticities for these interest rates. As expected, in all cases the short run elasticity is less that the long run elasticity. Furthermore, in all cases, the elasticity is very close to 1 in the long run. This is especially important for the 5-year conventional mortgage rate which plays a particularly important role in this model.

Table 4.9

Short and Long Run Elasticities
for Different Mortgage Rates

	Short Run	Long Run
1-Year Mortgage Rate	0.521	0.945
3-Year Mortgage Rate	0.377	0.754
5-Year Mortgage Rate	0.290	0.704
5-Year Conventional	0.569	0.979

4.7 Model Performance

In order to assess the performance of the equations estimated for the mortgage market, two exercises are undertaken. First, for the period over which the equations were estimated Appendix 4C sets out graphs for the actual and fitted values and the residuals for each of the equations presented in the text. In addition, Table 4.10 presents summary statistics for the sample period. Second, an out-of-sample forecast was undertaken for the four quarters of 1991 and summary statistics are provided in Table 4.11.

In the tables, two summary measures are presented: the root mean square error (RMSE) and the mean absolute percent error (MAPE). Since the RMSE has units which are the same as the dependent variable, the mean of the dependent variable is also provided. The MAPEs are unit-less; that is, they are percentages, not in the units of the dependent variable.

As the graphs in the appendix indicate, in general, the estimated equations track the sample period quite well. However, it is useful to summarize the results through a consideration of the RMSEs and MAPEs for the equations as set out in Table 4.10.

In the results for the units approved, we see that, except in one case, all of the MAPEs are less than 2.5 percent -- a very good result. In the case of new NHA multiple units approved, the MAPE is 4.3 percent and this is due to the rather large residuals in 1980:1, 1985:1, 1986:1 and 1986:2. It may be that social housing has something to do with these particular quarters (for example, a project ended or began).

For the average loan per unit, the MAPEs are much larger for new units than for existing units. The average loan for the existing units have MAPEs under 1 percent. For the new units, the MAPEs are largest for multiples. Once again this can be traced to some particular data points for conventional approvals and what appears to be a structural change in the data. Beginning in 1981:1 the average loan per unit series becomes much more volatile and this, in turn, may reflect definitional changes or data problems. For the average loan for NHA approved units, there appears to be a data problem in 1988:1 and 1988:2.

For the out-of-sample summary statistics, two versions of the RMSE and MAPE are presented in Table 4.11 -- a static and dynamic version. The static version uses actual values for the lagged dependent variable while the dynamic version uses simulated values of the lagged dependent variable. Therefore, the dynamic version allows for the propagation of errors and, consequently, we would expect that, in general, the dynamic RMSEs and MAPEs should be larger than the static version.

Table 4.10
Root Mean Squared Error and Mean Absolute Percentage Error of Housing Variables in the Sample Period

1. Units Approved

	Conventional	NHA
New Singles		
Sample Mean	9.180	8.370
RMSE	0.180	0.237
MAPE (percent)	1.548	2.227
New Multiples		
Sample Mean	8.624	9.102
RMSE	0.265	0.482
MAPE (percent)	2.411	4.279
Existing Singles		
Sample Mean	10.440	9.318
RMSE	0.164	0.189
MAPE (percent)	1.267	1.566
Existing Multiples		
Sample Mean	9.948	8.335
RMSE	0.201	0.245
MAPE (percent)	1.537	2.301

2. Average Loan per Unit

	Conventional	NHA
New Singles		
Sample Mean	61837.3	52795.8
RMSE	2083.9	1936.8
MAPE (percent)	3.018	2.855
New Multiples		
Sample Mean	36775.4	46015.9
RMSE	5051.7	3497.0
MAPE (percent)	14.182	7.501
Existing Singles		
Sample Mean	10.928	10.820
RMSE	0.027	0.027
MAPE (percent)	0.189	0.205
Existing Multiples		
Sample Mean	10.020	10.492
RMSE	0.071	0.105
MAPE (percent)	0.571	0.739

Note: The units for means and RMSE are as follows:
Approved Units -- log of the number of units approved
Average Loan per Unit -- dollars for new units approved and log of dollars for existing units approved.

In terms of units approved, the forecast errors are all within a tolerable range. In six out of the eight cases, the dynamic MAPEs are at 2 percent or below. The worst out-of-sample prediction is for new multiple NHA units approved and this corresponds to the worst fitting equation over the sample period.

For average loan per unit, new conventional and NHA multiple units perform poorly with dynamic MAPEs os 17.5 and 10.4 respectively. However, once again all the other dynamic MAPEs are at 2 percent or below -- with 4 of the cases below 1 percent.

Finally, Table 4.12 sets out the RMSEs and MAPEs for the four quarters of 1991 for the mortgage rates. Of most importance here is the 5-year conventional mortgage rate since this enters the equations for the number of units approved and the average loan per unit. For this rate the static and dynamic MAPEs are under 2 percent in this out-of-sample forecast. The other rates all have MAPEs at 5 percent or less.

Table 4.11

Root Mean Squared Error and Mean Absolute Percentage Error
Out-of-Sample Forecast of Housing Variables
(4-quarters of 1991)

1. Units Approved

	Conventional			NHA		
	Mean	Static	Dynamic	Mean	Static	Dynamic
New Singles						
RMSE	9.180	0.103	0.099	8.370	0.329	0.559
MAPE (percent)	--	1.088	1.048	--	2.990	6.644
New Multiples						
RMSE	8.790	0.192	0.184	8.764	0.524	0.700
MAPE (percent)	--	1.693	2.028	--	5.629	7.787
Existing Singles						
RMSE	11.652	0.108	0.122	10.064	0.127	0.159
MAPE (percent)	--	0.822	0.988	--	1.252	1.444
Existing Multiples						
RMSE	10.911	0.228	0.197	9.277	0.171	0.188
MAPE (percent)	--	1.814	1.768	--	1.147	1.712

2. Average Loan per Unit

	Conventional			NHA		
	Mean	Static	Dynamic	Mean	Static	Dynamic
New Singles						
RMSE	112137.4	5701.9	3579.1	100539.8	905.7	993.8
MAPE (percent)	--	3.602	2.395	--	0.657	0.721
New Multiples						
RMSE	60943.4	10856.2	12035.3	98497.2	8426.6	12049.9
MAPE (percent)	--	16.060	17.527	--	7.298	10.356
Existing Singles						
RMSE	11.314	0.054	0.087	11.354	0.053	0.062
MAPE (percent)	--	0.340	0.666	--	0.395	0.504
Existing Multiples						
RMSE	10.620	0.120	0.167	11.045	0.051	0.056
MAPE (percent)	--	0.903	1.305	--	0.340	0.339

Note: The units for means and RMSE are as follows:
Approved Units -- log of the number of units approved
Average Loan per Unit -- dollars for new units approved and log of dollars for existing units approved.

Table 4.12

Root Mean Squared Error and Mean Absolute Percentage Error
Out-of-Sample Forecast of Interest Rates
(4-quarters of 1991)

	Mean	Static	Dynamic
1-Year Mortgage Rate			
RMSE	10.085	0.388	0.835
MAPE (percent)	--	3.016	5.000
3-Year Mortgage Rate			
RMSE	10.898	0.288	0.761
MAPE (percent)	--	1.989	3.251
5-Year Mortgage Rate			
RMSE	11.130	0.419	0.817
MAPE (percent)	--	3.527	4.212
5-Year Conventional Mortgage Rate			
RMSE	11.155	0.240	0.652
MAPE (percent)	--	1.895	1.812

Note:
The mortgage rates and corresponding RMSEs are in percent.

APPENDIX 4A

Variable Definitions

MLANCONS	=	conventional mortgage approvals in units -- new single dwellings
MLANNHAS	=	NHA mortgage approvals in units -- new single dwellings
HSS	=	single housing starts in units
HSM	=	multiple housing starts in units
RMCON5YR	=	5-year conventional mortgage rate
D73	=	1 from 1973, Q1 through 1990, Q4; zero otherwise designed to capture the freeing of the mortgage rate
TIME	=	time trend; 1961, quarter 1 = 1.
MLAECONS	=	conventional mortgage approvals in units -- existing single units
MLAENHAS	=	NHA mortgage approvals in units -- existing single units
MLAECONM	=	conventional mortgage approvals in units -- existing multiple units
MLAENHAM	=	NHA mortgage approvals in units -- existing multiple units
KHS	=	stock of single dwelling housing in units
KHM	=	stock of multiple dwelling housing in units
DCMRP	=	dummy variable for the Canadian Mortgage Renewal Program
ALNCONS	=	average loan on conventional mortgage units -- new single units
ALNNHAS	=	average loan on NHA mortgage units -- new single units
ALNCONM	=	average loan on conventional mortgage units -- new multiple units
ALNNHAM	=	average loan on NHA mortgage units -- new multiple units
ALECONS	=	average loan on conventional mortgage units -- existing singles
ALENHAS	=	average loan on NHA mortgage units -- existing single units
ALECONM	=	average loan on conventional mortgage units -- existing multiples
ALENHAM	=	average loan on NHA mortgage units -- existing multiple units
MLSP	=	MLS price for resales
MLSS	=	MLS sales units
NHPI	=	new house price index
RGOC35	=	Government of Canada yield on 3-5 year bonds
POP2534	=	percentage of the total population aged 25-34.

other variables as described in the text

5. The Combination of Forecasts

5.1 Introduction

Given the information set on all current and past values of endogenous and exogenous variables in the data, forecasts of endogenous variables generated from the dynamic simultaneous equation model presented in Chapters 2, 3, and 4 may approximate their optimal forecasts. In order to achieve an improvement in forecasting, however, many macroeconomic forecasts often take into account vast information of a qualitative nature.

One may make adjustments to individual equations of the estimated model subjectively by adjusting the intercept terms and/or other parameter estimates. These "add factors" can be justified on the grounds that they incorporate into the forecasts any information or judgement on the factors that the forecaster has not explicitly brought or could not bring into the model. Good information may be available about exogenous shifts and structural breaks--changes in legislation and institutional arrangements may be known in advance so that the forecaster could modify the model.

The forecaster would then solve the (estimated and adjusted) model to obtain forecasts of the endogenous variables. However, if the forecaster has an a priori assessment of the likely range of future values, and if the forecasts obtained from the model fall outside the range, then the forecaster may modify them either directly or by readjusting the fitted structural equations and solving them again.

Judgemental adjustment is not the only way in which improvement in forecasting with a SEM is achieved. General rules in the literature of forecasting include:

(1) The larger the information set, the better the forecast, provided that the extra information is relevant; and
(2) if two or more forecasts of the same variable based on different forecasting approaches are combined, the combined forecasts will often be "better" than the constituents.

In this chapter we briefly discuss how forecasts from different approaches could be combined to yield better forecasts.

5.2 Combining Econometric and ARIMA Forecasts

Table 5.1 shows forecast errors of the starts of single-detached homes (HSS = D845155 in Cansim code) for four quarters in 1991 from two alternative forecasting methods: the first is the SEM in Chapters 2, 3, and 4 and the other an ARIMA model of Eq.(2.1) in

Part Two. The models were estimated with the sample data up to and including the last quarter of 1990, and the forecasts are ex post. Thus the reported one-step forecasts were generated by shifting the forecast origin and using all the available data at the origin without updating or re-estimating the models. The values for the root mean square error (RMSE) suggest that the SEM forecasts are better, on the average, than the ARIMA forecasts.

The final column of the table shows the combined forecasts and the forecast errors from a simple combined forecast, where

Combined forecast = 1/2 (SEM forecast + ARIMA forecast). (5.1)

The errors from this combined forecast are a simple average of the errors from the two constituent errors. The combined forecast has an RMSE of 1600, which is much less than the RMSE of the ARIMA forecast but not much larger than that of the SEM forecast. The values for the root mean square error (RMSE) suggest that the SEM forecasts are better, on the average, than the ARIMA forecasts.

Table 5.1

Forecasts and Forecast Errors of Housing Starts (HSS), 1991

(In units)

Quarter	SEM		ARIMA		Combined Forecast	
	Forecast	Error	Forecast	Error	Forecast	Error
1991:1	6578	-1994	12582	4010	9580	1010
1991:2	28208	651	30394	2837	29301	1744
1991:3	28635	255	29173	805	28904	530
1991:4	24109	2045	24884	2813	24497	2429
Mean		239		2616		1428
RMSE		1470		2858		1600

As another example of a combined forecast we present in Table 5.2 forecast errors of the investment in residential construction of single-detached homes (IHS = D845013 in Cansim code) for four quarters in 1991 from two alternative forecasting methods: the first is the SEM in Chapters 2, 3, and 4 and the other an ARIMA model of Eq.(2.27) in Part Two. The models were estimated with the sample data up to and including the last quarter of 1990, and the forecasts are ex post. The values for the root mean square error (RMSE) suggest that the SEM and the ARIMA forecasts are about the same, on the average.

The final column of the table shows the combined forecasts and the forecast errors from a simple average of the SEM and the ARIMA forecasts. The combined forecast has an RMSE of 294, which is about 10% less than the RMSE of the SEM or ARIMA forecast. Thus a very simple method of averaging has given a set of forecasts that is superior on the average to the two constituent forecasts.

A more sophisticated combining rule could provide further improvement. Let $f_T^{(1)}$ and $f_T^{(2)}$ be two one-step forecasts of Y_{T+1} with errors

$$e_T^{(1)} = Y_{T+1} - f_T^{(1)} \quad \text{and} \quad e_T^{(2)} = Y_{T+1} - f_T^{(2)}.$$

Suppose that the forecasts are unbiased. A combined forecast, taken to be a weighted average of the two forecasts,

$$f_T^{(c)} = k\, f_T^{(1)} + (1-k)\, f_T^{(2)} \tag{5.2}$$

is necessarily unbiased. The forecast error is

$$\begin{aligned} e_T^{(c)} &= Y_{T+1} - f_T^{(c)}. \\ &= k\, e_T^{(1)} + (1-k)\, e_T^{(2)} \end{aligned}$$

and the error variance is

$$\begin{aligned} \mathrm{Var}[e_T^{(c)}] &= k^2\, \mathrm{Var}[e_T^{(1)}] + (1-k)^2\, \mathrm{Var}[e_T^{(2)}] \\ &\quad + 2k(1-k)\, \mathrm{Cov}[e_T^{(1)}, e_T^{(2)}]. \end{aligned} \tag{5.3}$$

Table 5.2

Forecasts and Forecast Errors of New Residential

Investment in Single-Detached Homes (IHS), 1991

(In millions of current dollars)

Quarter	SEM		ARIMA		Combined Forecast	
	Forecast	Error	Forecast	Error	Forecast	Error
1991:1	2080	460	1973	353	2023	407
1991:2	2642	320	2838	516	2740	418
1991:3	3303	-281	3755	171	3529	-55
1991:4	2900	-163	3138	75	3019	-44
Mean		84		279		182
RMSE		324		326		294

Thus $Var[e_T^{(c)}]$ is minimized by taking

$$k=\frac{Var[e_T^{(2)}]-2Cov[e_t^{(1)},e_T^{(2)}]}{Var[e_T^{(1)}]+Var[E_T^{(2)}]-2Cov[e_T^{(1)},e_T^{(2)}]} \quad (5.4)$$

Hence, if this value of k is inserted into (5.2), then the resulting combined forecast will have a smaller error variance than the two constituent forecasts, and the combined forecast is superior to either constituent.

In practice, variances and covariances in (5.4) are never known. One could, however, estimate them from past forecast errors if these are available. If we use the four errors for 1991 in Table 5.2 to estimate the variances and covariances, the two forecasts for 1992:1 would be weight

$k = 0.245$

and the combined forecast would be

$$f_T^{(c)} = 0.245*\text{SEM forecast} + 0.755*\text{ARIMA forecast} \tag{5.5}$$

The combining technique can be generalized to the case of three or more forecasts of the same quantity. However, a regression method of combining forecasts proposed by Granger and Ramanathan (1984) is rather easy and has been shown to be good. One may just regress the actual value on its various forecasts and a constant without constraining the sum of the combination weights to be one. Applying this method to the four forecasts for 1991 presented in Table 5.2, we have obtained a combined forecast of housing starts for the first quarter of 1992 as

$$f_T^{(c)} = -6278 + 7.885*\text{SEM forecast} - 4.309*\text{ARIMA forecast} \tag{5.6}$$

When the past forecast errors are not available, the combined forecast of the type in (5.5) or (5.6) is not possible, and one may use the simple average type in (5.1) until experiences in combined forecasting and some forecast errors accumulate.

PART TWO

ARIMA MODELS OF THE HOUSING AND MORTGAGE MARKET VARIABLES

A simple but flexible approach to forecasting is to forecast the future values of a variable of interest on the basis of its own past history. One may first fit an autoregressive integrated moving average (ARIMA) model to the data and then extrapolate the series into the future using the fitted model. The model is "data based" in that it is specified from its goodness-of-fit to the data series.

In this part of the report we present a series of ARIMA models of Canadian housing sector and mortgage market variables. We present a brief summary of the ARIMA modelling techniques employed in our study. Detailed discussions on building ARIMA models can be found in many books including Box and Jenkins (1970), Vandaele (1983), Granger and Newbold (1986), and Park (1989).

The plan of this part of the report is as follows. In Chapter 1 a brief description of the multiplicative ARIMA model and the modelling strategies for the project are briefly described. Chapter 2 is concerned with the ARIMA models of the housing sector variables while Chapter 3 presents the ARIMA models of the mortgage market variables. Appendix A at the end of the report presents a list of variables and their data sources and Appendix C selected bibliography of ARIMA modelling.

1. Multiplicative Seasonal ARIMA Modelling

Almost all time series analyzed in the study display an exponential trend with gradual change in its spread over time. In such cases the logarithmic transformation of the original series is used to induce stationarity in variance.

Also common in time series is a component called "seasonality." It is any cyclical or periodic variation in a time series that repeats itself with a fixed period. Many monthly or quarterly series modelled have strong seasonal components with the seasonal span of twelve months or four quarters.

Many time series also display a rather smooth trend indicating a slow change in the mean over time. Such non-stationarity may be removed from the series by differencing consecutively a desired number of times. In some cases a given series may trend in annual steps, and require seasonal differencing to induce stationarity in mean. Most series modelled in the study require both regular differencing of order one and seasonal differencing of order one.

The multiplicative seasonal ARIMA model is useful in modelling times series in which seasonal variations with a known period of s occur. The model with the order p, d, q, P, D, Q and the seasonal span s, denoted by ARIMA $(p,d,q)x(P,D,Q)_s$, is written as

$$\phi(B)\Phi(B^s)\ (1 - B)^d\ (1 - B^s)^D\ X_t = \theta(B)\Theta(B^s)\ u_t, \tag{1.1}$$

where $\Phi(B^s)$ and $\Theta(B^s)$ are polynomials in B^s of degree P and Q, respectively, defined by

$$\Phi(B^s) = 1 - \Phi_1\ B^s - \dots - \Phi_P\ B^{Ps}$$

and

$$\Theta(B^s) = 1 - \Theta_1\ B^s - \dots - \Theta_Q\ B^{Qs},$$

and the polynomials $\phi(B)$ and $\theta(B)$ are as defined by

$$\phi(B) = 1 - \phi_1\ B - \dots - \phi_p\ B^p$$

and

$$\theta(B) = 1 - \theta_1\ B - \dots - \theta_q\ B^q.$$

The ARIMA model in (1.1) is the type that we have built for the housing and mortgage market variables.

At the stage of identifying an ARIMA model we have used various data analytic tools to arrive at initial guesses of the data transformation, the degree of differencing to induce stationarity, and the orders of the AR and MA polynomials in the model. Data analytic tools used for identification include time series plot, sample autocorrelation function, sample partial autocorrelation function, and extended sample autocorrelation function [Tsay and Tiao (1984)].

A model selection procedure based on these tools has been supplemented by the model selection criteria such as Akaike's final prediction error (FPE) criterion and Akaike's (1974) information criterion (AIC).

Once an ARIMA(p,d,q)x$(P,D,Q)_s$ model was identified, its parameters was estimated by the conditional least squares (LS) method. This is the method used by the SCA-UTS program.

Once a specified model was estimated, it was thoroughly checked for adequacy. Tools for diagnostic checking used include the residual autocorrelations and partial autocorrelations, and the Box-Pierce-Ljung portmanteau Q statistic for lack of fit test. Additional check for model adequacy was also made by changing the orders of the model, i.e., over- and under-fitting.

Once we have built an adequate ARIMA model, we can derive forecasts from it in a mechanical way. Given the full history of a time series, its conditional mean is the optimal forecast of the future value of the series in the sense of the minimum mean square

forecast error and can be consistently estimated from the estimated model.

When two or more models of a given series seemed to be adequate, out-of-sample forecasting performance was used as a means of selecting among the competing models. For comparisons of forecasting performance of competing models, we have generated one- to twelve-month ahead (or one- to four-quarter ahead) forecasts of a series for 1991 with the origin at the last period of 1990. A model with the smallest value of the mean absolute percentage error of forecasts or the root mean square percentage error of forecasts was chosen as the best.

The following two chapters present a set of ARIMA models of the housing sector and mortgage market variables that we have built along the line of the above discussions. Although some time series are available even from the 1950s, they might have been subject to significant structural changes, and the sample period was limited to the period from 1969 to 1990. Data availability constrained the sample period to be shorter than 1969-1990 for some housing sector variables. On the other hand, considering the institutional changes in the mortgage market, we used the sample period from 1974 to 1990 for the mortgage market variables although data were available for earlier years.

2. ARIMA Models of the Housing Sector Variables

One common characteristic of all the housing sector variables is that for inducing stationarity they required logarithmic transformation, regular differencing of order one, and seasonal differencing of order one. Thus, unless noted otherwise, all the variables in the following ARIMA models have been transformed such that we may write

$$Y_t = (1 - B)(1 - B^s) \log X_t,$$

where log stands for the natural logarithmic transformation and X_t for a variable being modelled in each equation.

Any data available prior to 1969 was not used in modelling to avoid undesirable consequences of parameter instability in the underlying structure of the data generating processes. Of course, for some series the sample period had to be much shorter due to the data limitation in availability.

All models were estimated with the SCA-UTS program of the Scientific Computing Associates. Figures in parentheses below parameter estimates are their large-sample standard errors, R^2 is the coefficient of determination, s is the standard error of the regression, T is the effective sample size after the desired

lagging and the required differencing for inducing stationarity, and Q(m) is the Ljung-Box statistic with m degrees of freedom.

2.1 Housing Starts: All Areas

Quarterly data from 1969:1 to 1990:4 give a total number of 88 observations for the housing starts series modelled in this section. As noted above, regular differencing of order one and seasonal differencing of order one for four quarters were taken of the logarithms of housing starts to induce stationarity in the starts series.

HSS (Singles) D845155

$$(2.1)\quad \underset{}{(1 - \underset{(.1840)}{1.2712}\, B + \underset{(.1666)}{.6900}\, B^2)}\, Y_t = (1 - \underset{(.2289)}{1.2050}\, B + \underset{(.2349)}{.4366}\, B^2)$$

$$(1 - \underset{(.0760)}{.7829}\, B^4)\, u_t$$

$R^2 = .845$, $s = .16692$, $T = 81$
$Q(4) = .3$, $Q(8) = 5.7$, $Q(12) = 6.0$

HSSD (Semi-detached) D845166

$$(2.2)\quad (1 + \underset{(.1084)}{.2766}\, B + \underset{(.1094)}{.2493}\, B^2)\, Y_t = (1 - \underset{(.0540)}{.9075}\, B^4)\, u_t$$

$R^2 = .747$, $s = .23322$, $T = 81$
$Q(4) = 2.3$, $Q(8) = 5.1$, $Q(12) = 10.7$

HSROW (Rows) D845177

$$(2.3)\quad Y_t = (1 - \underset{(.1018)}{.3884}\, B)(1 - \underset{(.0682)}{.8498}\, B^4)\, u_t$$

$R^2 = .626$, $s = .26002$, $T = 81$
$Q(4) = .5$, $Q(8) = 3.6$, $Q(12) = 8.8$

HSAPT (Apartments) D845188

$$(2.4)\quad \underset{}{(1 + \underset{(.1170)}{.5013}\, B^4)}\, Y_t = (1 - \underset{(.1111)}{.1912}\, B)(1 - \underset{(.1228)}{.3885}\, B^4)\, u_t$$

$R^2 = .653$, $s = .22165$, $T = 81$
$Q(4) = .4$, $Q(8) = 6.5$, $Q(12) = 13.4$

HSM (Multiples)

Housing starts of multi-family units are obtained by the sum of starts for semi-detached housing, row housing and apartments:

$$(2.5)\quad HSM = HSSD + HSROW + HSAPT$$

HSTOT (Total) D845199

Total housing starts are given by the following identity:

$$(2.6)\quad HSTOT = HSS + HSM$$

2.2 Housing Completions: All Areas

Quarterly data from 1969:1 to 1990:4 give a total number of 88 observations for the housing completions series modelled in this section. As noted above, regular differencing of order one and seasonal differencing of order one for four quarters were taken of the logarithms of housing completions to induce stationarity in the series.

HCS (Singles) D845737

$$(2.7)\quad (1 + \underset{(.1171)}{.0532}\, B - \underset{(.1127)}{.2053}\, B^2 + \underset{(.1130)}{.3013}\, B^3)(1 + \underset{(.1477)}{.3116}\, B^4)\, Y_t$$

$$= (1 - \underset{(.1250)}{.5669}\, B^4)\, u_t$$

$R^2 = .820$, $s = .12335$, $T = 76$
$Q(4) = .4$, $Q(8) = 3.8$, $Q(12) = 5.2$

HCSD (Semi-detached) D845748

$$(2.8)\quad Y_t = \underset{(.1006)}{(1 - .4042\, B)}\underset{(.0741)}{(1 - .7719\, B^4)}\, u_t$$

$R^2 = .811$, $s = .17006$, $T = 83$
$Q(4) = .7$, $Q(8) = 3.0$, $Q(12) = 5.2$

HCROW (Rows) D845759

$$(2.9)\quad Y_t = \underset{(.1020)}{(1 - .3451\, B)}\underset{(.0538)}{(1 - 1.0082\, B^4)}\, u_t$$

$R^2 = .724$, $s = .21164$, $T = 83$
$Q(4) = 1.9$, $Q(8) = 4.3$, $Q(12) = 7.2$

HCAPT (Apartments) D845770

$$(2.10)\quad (1 + \underset{(.1122)}{.5291}\, B + \underset{(.1088)}{.2201}\, B^2)\, Y_t = (1 - \underset{(.0720)}{.8249}\, B^4)\, u_t$$

$R^2 = .725$, $s = .16233$, $T = 81$
$Q(4) = .9$, $Q(8) = 7.7$, $Q(12) = 13.9$

HCM (Multiples)

Housing completions of multiples are obtained by summing up those for semi-detached housing, row housing, and apartments:

(2.11) HCM = HCSD + HCROW + HCAPT

HCTOT (Total) D845792

Total housing completions are defined as the following sum:

(2.12) HCTOT = HCS + HCM

2.3 Housing Starts: Centres of 10,000 and Over

This section presents ARIMA models of the housing starts series of centres with a population of 10,000 or more using the monthly data from 1969:1 to 1990:12 (a total number of 264 observations). As noted above, regular differencing of order one and seasonal

differencing of order one for 12 months were taken of the logarithms of housing starts to induce stationarity in the series.

HSCS (Singles) D849796

$$(2.13)\quad \underset{(.0746)}{(1 + .2504\, B^{12})}\, Y_t = \underset{(.0572)}{(1 - .6666\, B^{12})}\, u_t$$

$R^2 = .920$, $s = .12042$, $T = 239$
$Q(12) = 14.9$, $Q(24) = 28.7$, $Q(36) = 40.3$

HSCSD (Semi-detached) D849807

$$(2.14)\quad Y_t = (1 - \underset{(.0620)}{.3564}\, B - \underset{(.0656)}{.1169}\, B^2 - \underset{(.0619)}{.1897}\, B^3)$$

$$(1 - \underset{(.0290)}{.9194}\, B^{12})\; u_t$$

$R^2 = .800$, $s = .22380$, $T = 251$
$Q(12) = 5.4$, $Q(24) = 14.8$, $Q(36) = 23.3$

HSCROW (Rows) D849818

$$(2.15)\quad (1 - \underset{(.0900)}{.1620}\, B)\, Y_t = (1 - \underset{(.0592)}{.7614}\, B)\, (1 - \underset{(.0292)}{.9400}\, B^{12})\, u_t$$

$R^2 = .554$, $s = .31661$, $T = 250$
$Q(12) = 5.3$, $Q(24) = 11.9$, $Q(36) = 19.7$

HSCAPT (Apartments) D849829

$$(2.16)\quad (1 - \underset{(.1215)}{.2028}\, B)\, Y_t = (1 - \underset{(.0955)}{.6347}\, B)\, (1 - \underset{(.0336)}{.8412}\, B^{12})\, u_t$$

$R^2 = .640$, $s = .25767$, $T = 250$
$Q(12) = 5.9$, $Q(24) = 23.1$, $Q(36) = 40.7$

HSCM (Multiples)

(2.17) HSCM = HSCSD + HSCROW + HSCAPT

HSCTOT (Total) D849795

(2.18) HSCTOT = HSCS + HSCM

2.4 Housing Completions: Centres of 10,000 and Over

In this section we present ARIMA models of the housing completions series for centres of 10,000 and over based on monthly data from 1969:1 to 1990:12 (T = 264). As noted above, regular differencing of order one and seasonal differencing of order one for 12 months were taken of the logarithms of housing completions to induce stationarity in the series.

HCCS (Singles) D849841

$$(1 + \underset{(.0796)}{.1686}\, B^{12})\, Y_t = (1 - \underset{(.0613)}{.3278}\, B)\,(1 - \underset{(.0600)}{.6542}\, B^{12})\, u_t \tag{2.19}$$

$R^2 = .890$, $s = .11276$, $T = 239$
$Q(12) = 17.8$, $Q(24) = 27.7$, $Q(36) = 46.3$

HCCSD (Semi-detached) D849852

$$(1 - \underset{(.1001)}{.2221}\, B)\, Y_t = (1 - \underset{(.0706)}{.7223}\, B)\,(1 - \underset{(.0440)}{.7544}\, B^{12})\, u_t \tag{2.20}$$

$R^2 = .819$, $s = .17967$, $T = 250$
$Q(12) = 6.8$, $Q(24) = 19.0$, $Q(36) = 30.6$

HCCROW (Rows) D849863

$$(1 + \underset{(.0677)}{.1508}\, B^{12})\, Y_t = (1 - \underset{(.0468)}{.6889}\, B)\,(1 - \underset{(.0356)}{.8921}\, B^{12})\, u_t \tag{2.21}$$

$R^2 = .626$, $s = .27576$, $T = 239$
$Q(12) = 1.8$, $Q(24) = 17.2$, $Q(36) = 23.2$

HCCAPT (Apartments) D849874

(2.22) $$Y_t = (1 - \underset{(.0381)}{.7836}\, B)(1 - \underset{(.0392)}{.8092}\, B^{12})\, u_t$$

$R^2 = .588$, $s = .23965$, $T = 251$
$Q(12) = 5.6$, $Q(24) = 24.4$, $Q(36) = 39.3$

HCCM (Multiples)

(2.23) HCCM = HCCSD + HCCROW + HCCAPT

HCCTOT (Total) D849840

(2.24) HCCTOT = HCCS + HCCM

2.5 Resale Market (from Multiple Listing Services of CREA)

MLSP (MLS price per unit in dollars)

Quarterly data from 1977:1 to 1990:4 give a total number of only 56 observations for the average MLS price series modelled in this section. Regular differencing of order one and seasonal differencing of order one for 4 quarters were taken of the logarithms of the original series to induce its stationarity.

(2.25) $$(1 - \underset{(.1432)}{.3205}\, B)(1 + \underset{(.1312)}{.6901}\, B^4)\, Y_t = u_t$$

$R^2 = .987$, $s = .03615$, $T = 46$
$Q(4) = .8$, $Q(8) = 3.1$, $Q(12) = 7.9$

MLSS (MLS sales units - not seasonally adjusted)

Monthly data from 1971:1 to 1990:09 give a total number of 237 observations for the MLS sales series. Regular differencing of order one and seasonal differencing of order one for 12 months were taken of the logarithms of the original series to induce its stationarity.

$$(2.26)\quad \underset{(.0683)}{(1 + .2703\, B^{13})}\, Y_t = (1 - \underset{(.0678)}{.1223\, B} - \underset{(.0677)}{.1273\, B^2} - \underset{(.0684)}{.1267\, B^3}$$

$$- \underset{(.0686)}{.2059\, B^4})\,(1 - \underset{(.335)}{1.0084\, B^{12}})\, u_t$$

$R^2 = .948$, $s = .097571$, $T = 211$
$Q(12) = 5.0$, $Q(24) = 20.5$, $Q(36) = 37.9$

2.6 Residential Investment (in thousands of dollars)

Quarterly data from 1969:1 to 1990:4 give a total number of 88 observations for residential investment series modelled in this section. Regular differencing of order one and seasonal differencing of order one for 4 quarters were taken of the logarithms of the original series to induce its stationarity.

IHS (Singles) D845013

$$(2.27)\quad (1 - \underset{(.0990)}{.7864\, B} + \underset{(.1088)}{.4739\, B^2})\, Y_t = (1 - \underset{(.0702)}{.7940\, B^4})\, u_t$$

$R^2 = .983$, $s = .09424$, $T = 81$
$Q(4) = 1.4$, $Q(8) = 4.1$, $Q(12) = 6.7$

IHSD (Semi-detached) D845014

$$(2.28)\quad (1 - \underset{(.1059)}{.3543\, B} + \underset{(.1058)}{.3808\, B^2})\, Y_t = (1 - \underset{(.0817)}{.6994\, B^4})\, u_t$$

$R^2 = .930$, $s = .12895$, $T = 81$
$Q(4) = .5$, $Q(8) = 3.3$, $Q(12) = 5.3$

IHROW (Rows) D845015

$$(2.29)\quad Y_t = (1 + \underset{(.0972)}{.4775\, B})\,(1 - \underset{(.0671)}{.7838\, B^4})\, u_t$$

$R^2 = .973$, $s = .11185$, $T = 83$
$Q(4) = .5$, $Q(8) = 2.2$, $Q(12) = 4.2$

IHAPT (Apartments) D845016

$$(2.30)\quad \underset{(.1371)}{(1 + .3528\, B^4)}\, Y_t = (1 + \underset{(.0991)}{.5129}\, B)(1 - \underset{(.1136)}{.5143}\, B^4)\, u_t$$

$R^2 = .950$, $s = .10082$, $T = 79$
$Q(4) = .6$, $Q(8) = 9.9$, $Q(12) = 19.2$

IHM (Multiples)

(2.31) IHM = IHSD + IHROW + IHAPT

IHNEW (All types) D845012

(2.32) IHNEW = IHS + IHM

IHCON (Conversions) D845017

$$(2.33)\quad Y_t = (1 - \underset{(.0887)}{.5874}\, B)(1 - \underset{(.0479)}{.9776}\, B^4)\, u_t$$

$R^2 = .926$, $s = .30354$, $T = 83$
$Q(4) = 4.3$, $Q(8) = 6.4$, $Q(12) = 10.5$

IHIMP (Improvements) D845019

$$(2.34)\quad (1 + \underset{(.0957)}{1.0983}\, B + \underset{(.0817)}{.6005}\, B^2)\, Y_t = (1 + \underset{(.1014)}{.7493}\, B)\, u_t$$

$R^2 = .994$, $s = .07798$, $T = 81$
$Q(4) = 1.2$, $Q(8) = 5.7$, $Q(12) = 9.3$

IHCOT (Cottages) D845020

$$(2.35)\quad (1 + \underset{(.1051)}{.2293}\, B + \underset{(.1104)}{.5700}\, B^2)(1 + \underset{(.1314)}{.8757}\, B^4 + \underset{(.1638)}{.3908}\, B^8$$

$$+ \underset{(.1373)}{.5450}\, B^{12})\, Y_t = u_t$$

$R^2 = .983$, $s = .12245$, $T = 69$
$Q(4) = .9$, $Q(8) = 5.3$, $Q(12) = 6.3$

IHMOB (Mobile homes) D845021

$$(2.36) \quad (1 + \underset{(.1100)}{.4597}\, B^4)\, Y_t = (1 - \underset{(.1119)}{.2506}\, B)\, u_t$$

$R^2 = .814$, $s = .22140$, $T = 83$
$Q(4) = 1.1$, $Q(8) = 2.3$, $Q(12) = 8.0$

IHACQ (Acquisition costs) D845018

$$(2.37) \quad (1 + \underset{(.1036)}{.3233}\, B)\, Y_t = (1 - \underset{(.0717)}{.7664}\, B^4)\, u_t$$

$R^2 = .980$, $s = .12228$, $T = 82$
$Q(4) = 2.6$, $Q(8) = 3.9$, $Q(12) = 5.5$

IHO (Other)

$$(2.38) \quad IHO = IHNCON + IHIMP + IHCOT + IHMOB + IHACQ$$

IHTOT (Total) D845011

$$(2.39) \quad IHTOT = IHNEW + IHO$$

2.7 New House Price Index

Monthly data from 1976:1 to 1990:12 give a total number of 180 observations each for the new house price index, its house component, and its land component. The modelled series were obtained by dividing the original series by 100, taking their logarithms, and differencing and seasonally differencing once each.

NHPI (New house price index) D698200

$$(2.40) \quad (1 - \underset{(.0345)}{.9286}\, B)\, Y_t = (1 - \underset{(.0821)}{.4214}\, B)\, u_t$$

$R^2 = 1.000$, $s = .004552$, $T = 178$
$Q(12) = 8.9$, $Q(24) = 30.2$, $Q(36) = 43.4$

NHPIH (New house price index--house only) D698201

$$(2.41)\quad (1 - \underset{(.0540)}{.9092}\, B)Y_t = (1 - \underset{(.0933)}{.6713}\, B)\, u_t$$

$R^2 = .998$, $s = .010998$, $T = 178$
$Q(12) = 3.2$, $Q(24) = 6.2$, $Q(36) = 8.5$

NHPIL (New house price index--land only) D698202

$$(2.42)\quad (1 - \underset{(.0387)}{.9158}\, B)Y_t = (1 - \underset{(.0836)}{.4864}\, B)\, u_t$$

$R^2 = .999$, $s = .0070295$, $T = 178$
$Q(12) = 11.2$, $Q(24) = 27.7$, $Q(36) = 32.5$

2.8 Consumer Price Index

Monthly data from 1969:1 to 1990:12 give a total number of 264 observations each for CPIHT the housing component of the consumer price index (CPI), CPIHR the rental accommodation component of CPI, and CPIHO the owner-occupied accommodation component of CPI. The modelled series were obtained by dividing the original series by 100, taking their logarithms, and taking regular differencing of order one and seasonal differencing of order one for 12 months.

CPIHT (CPI - housing) P484164

$$(2.43)\quad (1 - \underset{(.0901)}{.8204}\, B - \underset{(.0776)}{.1351}\, B^2)Y_t$$

$$= (1 - \underset{(.0711)}{.7227}\, B)(1 - \underset{(.0439)}{.7320}\, B^{12})\, u_t$$

$R^2 = 1.00$, $s = .0026003$, $T = 249$
$Q(12) = 20.3$, $Q(24) = 36.0$, $Q(36) = 43.3$

CPIHR (CPI - rented accommodation) P484167

$$(2.44)\quad (1 - \underset{(.1039)}{.1406}\,B - \underset{(.0792)}{.7759}\,B^2)Y_t = (1 - \underset{(.0905)}{.6589}\,B)(1 - \underset{(.0590)}{.3864}\,B^{12})\,u_t$$

$R^2 = 1.00$, $s = .0018367$, $T = 249$
$Q(12) = 6.7$, $Q(24) = 22.2$, $Q(36) = 33.8$

CPIHO (CPI - owned accommodation) P484171

$$(2.45)\quad (1 - \underset{(.1184)}{.5846}\,B - \underset{(.0781)}{.2684}\,B^2)(1 - \underset{(.0641)}{.2598}\,B^{12})\,Y_t = (1 - \underset{(.1157)}{.5204}\,B)(1 - \underset{(.0323)}{.9489}\,B^{12})\,u_t$$

$R^2 = 1.00$, $s = .0036126$, $T = 237$
$Q(12) = 7.7$, $Q(24) = 19.6$, $Q(36) = 33.4$

2.9 Construction Cost Index

BCWRI (Basic construction wage rate index) D477450

Monthly data from 1971:1 to 1990:5 give a total number of 233 observations for the basic construction wage rate index. The series was divided by 100 before its logarithm was taken. Then regular differencing of order one and seasonal differencing of order one for 12 months were taken to induce the stationarity of the series.

$$(2.46)\quad (1 - \underset{(.0713)}{.0267}\,B^{12} + \underset{(.0788)}{.3056}\,B^{24})Y_t = (1 + \underset{(.0749)}{.1507}\,B)(1 - \underset{(.0497)}{.8352}\,B^{12})\,u_t$$

$R^2 = 1.00$, $s = .0077822$, $T = 196$
$Q(12) = 18.7$, $Q(24) = 21.3$, $Q(36) = 43.3$

CBMPI (Construction building material index) D649830

Monthly data from 1981:1 to 1990:12 give a total number of 114 observations for the basic construction wage rate index. The series was divided by 100 before its logarithm was taken. Then regular differencing of order one and seasonal differencing of order one for 12 months were taken to induce the stationarity of the series.

$$(2.47) \quad (1 + \underset{(.0873)}{.5832}\, B^{12})Y_t = (1 + \underset{(.1066)}{.1814}\, B)\, u_t$$

$R^2 = .997$, $s = .0067479$, $T = 89$

$Q(12) = 12.2$, $Q(24) = 27.6$, $Q(36) = 49.1$

3. ARIMA Models of the Mortgage Market Variables

3.1 Mortgage Loans Approval (in Units)

Monthly data from 1969:1 to 1991:12 give a total number of 276 observations for each series of units of the mortgage loans approved. We used the data from 1969:1 to 1990:12 for estimation. The remaining 12 observations in 1991 were set aside for post-sample prediction testing of the estimated ARIMA models.

In all cases, we took the logarithmic transformation of the original series to induce stationarity in variance. In majority of cases, regular differencing of order one and seasonal differencing of order one for 12 months were required to induce stationarity in the series to model. The Y_t variable in the fitted equations presented below is defined by

$$Y_t = (1 - B) (1 - B^{12}) \ln X_t ,$$

where X_t stands for the original series. The effective sample size for the modelling results reported below is therefore 251.

The estimation results presented below include parameter estimates and their standard errors in parentheses as well as R-square (R^2), residual standard error (s), the effective sample size (T), the Box-Pierce Q statistic (Q(m), m=12, 24, 36), and the mean of the (differenced) series.

A. For new housing

MLANNHAS (NHA singles) H328

$$(3.1)\quad (1 + \underset{(.0600)}{.4086} B + \underset{(.0650)}{.1446} B^2 + \underset{(.0645)}{.1861} B^3$$

$$+ \underset{(.0645)}{.1081} B^4 + \underset{(.0596)}{.2603} B^5) Y_t = (1 - \underset{(.0320)}{.8967} B^{12}) u_t$$

R^2 = .791, s = .29485, T = 258
Q(12) = 5.6, Q(24) = 20.1, Q(36) = 33.0
Mean of the (differenced) series = .0008

MLANNHAM (NHA multiples) H329

$$(3.2)\quad \underset{(.0878)}{(1 - .3317\, B)}\, Y_t = (1 - \underset{(.0541)}{.8110})(1 - \underset{(.0352)}{.8735}\, B^{12})\, u_t$$

$R^2 = .700$, $s = .50635$, $T = 262$
$Q(12) = 9.6$, $Q(24) = 17.1$, $Q(36) = 31.4$
Mean of the (differenced) series = .0059

MLANNHA (NHA total) H327

(3.3) MLANNHA = MLANNHAS + MLANNHAM

MLANCONS (Conventional singles) H331

$$(3.4)\quad (1 - \underset{(.0615)}{.0662}\, B + \underset{(.0605)}{.1152}\, B^2)\, Y_t = (1 - \underset{(.0280)}{.9366}\, B^{12})\, u_t$$

$R^2 = .869$, $s = .18970$, $T = 261$
$Q(12) = 13.7$, $Q(24) = 33.1$, $Q(36) = 45.5$
Mean of the (differenced) series = .0200

MLANCONM (Conventional multiples) H332

$$(3.5)\quad (1 + \underset{(.0808)}{.3566}\, B)(1 - B)\ln X_t = (1 - \underset{(.0474)}{.8220}\, B)\, u_t$$

$R^2 = .664$, $s = .35150$, $T = 274$
$Q(12) = 5.9$, $Q(24) = 22.8$, $Q(36) = 37.0$
Mean of the (differenced) series = .0216

MLANCON (Conventional total) H330

(3.6) MLANCON = MLANCONS + MLANCONM

MLAN (Total) H326

(3.7) MLAN = MLANNHA + MLANCON

B. For existing housing

MLAENHAS (NHA singles) H342

$$(3.8)\quad \underset{(.0622)}{(1 + .1447\,B^4)}\,\underset{(.0547)}{(1 - .4692\,B^{12})}\,Y_t$$

$$= (1 + \underset{(.0617)}{.0037\,B} - \underset{(.0623)}{.1277\,B^2})\,u_t$$

R^2 = .936, s = .23044, T = 259
Q(12) = 15.2, Q(24) = 36.2, Q(36) = 49.5
Mean of the (differenced) series = .0057

MLAENHAM (NHA multiples) H343

$$(3.9)\quad Y_t = (1 - \underset{(.0603)}{.6288\,B} - \underset{(.0608)}{.1340\,B^2})(1 - \underset{(.0335)}{.7915\,B^{12}})\,u_t$$

R^2 = .890, s = .44541, T = 263
Q(12) = 15.3, Q(24) = 40.8, Q(36) = 48.6
Mean of the (differenced) series = -.0371

MLAENHA (NHA total) H341

(3.10) MLAENHA = MLAENHAS + MLAENHAM

MLAECONS (Conventional singles) H345

$$(3.11)\quad (1 - \underset{(.1031)}{.6306\,B})\,Y_t = (1 - \underset{(.1098)}{.6086\,B} - \underset{(.0694)}{.2468\,B^2})$$

$$(1 - \underset{(.0287)}{1.0107\,B^2})\,u_t$$

R^2 = .941, s = .19342, T = 262
Q(12) = 10.5, Q(24) = 29.9, Q(36) = 38.8
Mean of the (differenced) series = .0016

MLAECONM (Conventional multiples) H346

$$(3.12)\quad (\ 1 + \underset{(.0595)}{.1534}\ B + \underset{(.0602)}{.1557}\ B^2 - \underset{(.0604)}{.0383}\ B^3 + \underset{(.0597)}{.2136}\ B^4\ )$$

$$(\ 1 - B\ )\ \ln X_t = u_t$$

$R^2 = .875$, $s = .28141$, $T = 271$
$Q(12) = 15.6$, $Q(24) = 45.4$, $Q(36) = 58.1$
Mean of the (differenced) series = .0016

MLAECON (Conventional total) H344

(3.13) MLAECON = MLAECONS + MLAECONM

MLAE (Total) H340

(3.14) MLAE = MLAENHA + MLAECON

3.2 Mortgage Loans Approval (in thousands of dollars)

Monthly data from 1969:1 to 1991:12 give a total number of 276 observations for each series of the mortgage loan values approved. The 12 monthly observations in 1991 were set aside for post-sample prediction testing of the estimated ARIMA models. In the majority of cases, we took the logarithmic transformation and then regular differencing of order one and seasonal differencing of order one for 12 months in order to induce stationarity in the series to model. Unless otherwise indicated, the effective sample size for the modelling results reported below is therefore 251.

A. For new housing

MLNNHASV (NHA singles) H335

$$(3.15)\quad (\ 1 + \underset{(.1514)}{.3629}\ B - \underset{(.1110)}{.4747}\ B^2\ )\ Y_t = (\ 1 - \underset{(.1439)}{.0457}\ B - \underset{(.0887)}{.5881}\ B^2)$$

$$(1 - \underset{(.0315)}{.9031}\ B^{12}\ )\ u_t$$

R^2 = .752,   s = .29543,   T = 261
Q(12) = 14.8,   Q(24) = 27.8,   Q(36) = 42.3
Mean of the (differenced) series = .0013

MLNNHAMV (NHA multiples) H336

$$(3.16) \quad (1 - \underset{(.0868)}{.3142} B) Y_t = (1 - \underset{(.0532)}{.8108} B) (1 - \underset{(.0369)}{.8557} B^{12}) u_t$$

R^2 = .549,   s = .49480,   T = 262
Q(12) = 10.7,   Q(24) = 17.1,   Q(36) = 30.9
Mean of the (differenced) series = .0063

MLNNHAV (NHA total) H334

$$(3.17) \quad \text{MLNNHAV} = \text{MLNNHAV} + \text{MLNNHAV}$$

MLNCONSV (Conventional singles) H338

$$(3.18) \quad (1 - \underset{(.0875)}{.8964} B + \underset{(.0641)}{.1325} B^2) Y_t = (1 - \underset{(.0678)}{.8777} B) (1 - \underset{(.0321)}{.8800} B^{12}) u_t$$

R^2 = .951,   s = .19738,   T = 261
Q(12) = 5.8,   Q(24) = 24.2,   Q(36) = 40.7
Mean of the (differenced) series = -.0022

MLNCONMV (Conventional multiples) H339

$$(3.19) \quad (1 - \underset{(.0820)}{.3097} B - \underset{(.0565)}{.1500} B^{11}) (1 - B) \ln X_t = (1 - \underset{(.0500)}{.8118} B) u_t$$

R^2 = .763,   s = .37701,   T = 264
Q(12) = 6.6,   Q(24) = 26.9,   Q(36) = 45.5
Mean of the (differenced) series = .0261

MLNCONV (Conventional total) H337

(3.20) $$MLNCONV = MLNCONSV + MLNCONMV$$

MLNV (Total) H333

(3.21) $$MLNV = MLNNHAV + MLNCONV$$

B. For existing housing

MLENHASV (NHA singles) H349

(3.22) $$\underset{}{(\,1 + \underset{(.0617)}{.0175}\,B + \underset{(.0616)}{.1426}\,B^2 - \underset{(.0613)}{.0499}\,B^3 + \underset{(.0612)}{.1108}\,B^4\,)}$$

$$Y_t = (\,1 + \underset{(.0271)}{.9466}\,B^{12}\,)\,u_t$$

$R^2 = .975$, $s = .22491$, $T = 259$
$Q(12) = 17.9$, $Q(24) = 42.1$, $Q(36) = 57.1$
Mean of the (differenced) series = -.0096

MLENHAMV (NHA multiples) H350

(3.23) $$(\,1 - \underset{(.1117)}{.1877}\,B + \underset{(.0720)}{.1658}\,B^2\,)(\,1 + \underset{(.0651)}{.1008}\,B^{12}\,)$$

$$Y_t = (\,1 - \underset{(.0998)}{.6289}\,B\,)(1 - \underset{(.0777)}{.6574}\,B^{12} - \underset{(.0725)}{.1623}\,B^{24})\,u_t$$

$R^2 = .962$, $s = .33969$, $T = 249$
$Q(12) = 18.2$, $Q(24) = 28.8$, $Q(36) = 43.1$
Mean of the (differenced) series = -.0224

MLENHAV (NHA total) H348

(3.24) $$MLENHAV = MLENHASV + MLENHAMV$$

MLECONSV (Conventional singles) H352

$$(3.25)\quad \underset{(.0624)}{(1 - .1970\, B^{12})}\,(1 - B)\ \ln X_t$$

$$= (1 + \underset{(.0614)}{.1535}\, B - \underset{(.0606)}{.1849}\, B^2 - \underset{(.0577)}{.2238}\, B^3 - \underset{(.0624)}{.2503}\, B^4)\ u_t$$

$R^2 = .972$, $s = .21719$, $T = 263$
$Q(12) = 8.5$, $Q(24) = 30.0$, $Q(36) = 41.5$
Mean of the (differenced) series = .0133

MLECONMV (Conventional multiples) H353

$$(3.26)\quad \underset{(.0602)}{(1 - .1914\, B^{12})}\,(1 - B)\ \ln X_t$$

$$= (1 - \underset{(.0599)}{.1448}\, B - \underset{(.0600)}{.1426}\, B^2 - \underset{(.0603)}{.0527}\, B^3 - \underset{(.0590)}{.2200}\, B^4)\ u_t$$

$R^2 = .962$, $s = .26992$, $T = 263$
$Q(12) = 9.4$, $Q(24) = 36.3$, $Q(36) = 42.6$
Mean of the (differenced) series = .0274

MLECONV (Conventional total) H351

(3.27) MLECONV = MLECONSV + MLECONMV

MLEV (Total) H347

(3.28) MLEV = MLENHAV + MLECONV

3.3 Mortgage Rates

Sample periods for the monthly mortgage rate series varied among different series. For the chartered bank typical rates for one and three years data were available from 1980:1 to 1990:12 with a total number of 130 observations. For the chartered bank typical rates for five year mortgage data were available from 1973:1 to 1990:12 with a total number of 216 observations. For the conventional five year mortgage lending rate sample period was set from 1969:1 to 1990:12 with a total number of 264 observations. In order to

induce stationarity in the series to model, we have divided the original percentage figures by 100 to express the rates in decimal fraction, taken their logarithmic transformation, and then regular differencing of order one and seasonal differencing of order one for 12 months.

RMCB1 (Chartered bank typical rate on 1 year mortgage) B14050

$$(3.29)\quad \underset{(.0833)}{(1 - .2711\,B)}\, Y_t = u_t$$

$R^2 = .951$, $s = .0459765$, $T = 130$
$Q(12) = 5.7$, $Q(24) = 11.6$, $Q(36) = 18.4$

RMCB3 (Chartered bank typical rate on 3 year mortgage) B14052

$$(3.30)\quad \underset{(.0836)}{(1 - .2475\,B)}\, Y_t = u_t$$

$R^2 = .948$, $s = .0421263$, $T = 130$
$Q(12) = 5.9$, $Q(24) = 15.9$, $Q(36) = 27.1$

RMCB5 (Chartered bank typical rate on 5 year mortgage) B14051

$$(3.31)\quad (1 - \underset{(.0680)}{.2603}\,B + \underset{(.1254)}{.1254}\,B^2)\, Y_t = u_t$$

$R^2 = .952$, $s = .0390382$, $T = 213$
$Q(12) = 13.4$, $Q(24) = 28.5$, $Q(36) = 36.2$

RMCON5 (Conventional 5 year mortgage lending rate) B14024

$$(3.32)\quad (1 - \underset{(.0629)}{.5048}\,B + \underset{(.0702)}{.1841}\,B^2 + \underset{(.0698)}{.0619}\,B^3 + \underset{(.0676)}{.0254}\,B^4$$
$$- \underset{(.0673)}{.1927}\,B^5 + \underset{(.0678)}{.1591}\,B^6 + \underset{(.0674)}{.1312}\,B^7 - \underset{(.0679)}{.2711}\,B^8$$
$$+ \underset{(.0701)}{.2329}\,B^9 - \underset{(.0706)}{.1008}\,B^{10} + \underset{(.0635)}{.1232}\,B^{11})\, Y_t$$

$R^2 = .977$, $s = .0276303$, $T = 252$
$Q(12) = 1.6$, $Q(24) = 19.9$, $Q(36) = 25.9$

APPENDIX A LIST OF VARIABLES AND DATA SOURCES

Name	CANSIM Code	Frequency	Description	Sample Period
(1) Housing Starts (in Units): All Areas				
HSTOT	D845199	Q	Total	1961:1-1991:4
HSS	D845155	Q	Singles	"
HSSD	D845166	Q	Semi-detached	"
HSROW	D845177	Q	Rows	"
HSAPT	D845188	Q	Apartments	"
(2) Housing Completions (in Units): All Areas				
HCTOT	D845792	Q	Total	1961:1-1991:4
HCS	D845737	Q	Singles	"
HCSD	D845748	Q	Semi-detached	"
HCROW	D845759	Q	Rows	"
HCAPT	D845770	Q	Apartments	"
(3) Housing Starts (in Units): Centres of 10,000 and Over				
HSCTOT	D849795	M	Total	1967:01-1992:02
HSCS	D849796	M	Singles	"
HSCSD	D849807	M	Semi-detached	"
HSCROW	D849818	M	Rows	"
HSCAPT	D849829	M	Apartments	"
(4) Housing Completions (in Units): Centres of 10,000 and Over				
HCCTOT	D849840	M	Total	1967:01-1992:02
HCCS	D849841	M	Singles	"
HCCSD	D849852	M	Semi-detached	"
HCCROW	D849863	M	Rows	"
HCCAPT	D849874	M	Apartments	"
(5) Resale Market (from Multiple Listing Services of CREA)				
MLSP	(CREA)	Q	MLS price per unit in dollars	1977:1 - 1990:4
MLSS	(CREA)	M	MLS sales units - seasonally unadjusted	1971:01-1990:09

(6) New House Price Index (1986 = 100)

NHPI*	D698200	M	New house price index	1971:01-1992:02

(7) Consumer Price Index (1986 = 100)

CPI	P484000	M	CPI - all items	1961:01-1992:02
CPIHT	P484164	M	CPI - housing	"
CPIHR	P484167	M	CPI - rented accommodation	"

(8) Residential Investment (in thousands of dollars)

IHTOT	D845011	Q	Total	1961:1 - 1991:4
IHNEW	D845012	Q	New - all types	"
IHS	D845013	Q	New - singles	"
IHSD	D845014	Q	New - semi-detached	"
IHROW	D845015	Q	New - row housing	"
IHAPT	D845016	Q	New - apartments	"
IHCON	D845017	Q	Conversions	"
IHIMP	D845019	Q	Improvements	"
IHCOT	D845020	Q	Cottages	"
IHMOB	D845021	Q	Mobile homes	"
IHACQ	D845018	Q	Acquisition costs	"

(9) Mortgage Loans Approval (in Units)

A. For new housing

MLAN	H326	M	Total	1969:01-1991:12
MLANNHA	H327	M	NHA total	"
MLANNHAS	H328	M	NHA singles	"
MLANNHAM	H329	M	NHA multiples	"
MLANCON	H330	M	Conventional total	"
MLANCONS	H331	M	Conventional singles	"
MLANCONM	H332	M	Conventional multiples	"

B. For existing housing

MLAE	H340	M	Total	1969:01-1991:12
MLAENHA	H341	M	NHA total	"
MLAENHAS	H342	M	NHA singles	"
MLAENHAM	H343	M	NHA multiples	"
MLAECON	H344	M	Conventional total	"
MLAECONS	H345	M	Conventional singles	"
MLAECONM	H346	M	Conventional multiples	"

(10) Mortgage Loans Approval (in thousands of dollars)

A. For new housing

MLNV	H333	M	Total	1969:01-1991:12
MLNNHAV	H334	M	NHA total	"
MLNNHAVS	H335	M	NHA singles	"
MLNNHAVM	H336	M	NHA multiples	"
MLNCONV	H337	M	Conventional total	"
MLNCONVS	H338	M	Conventional singles	"
MLNCONVM	H339	M	Conventional multiples	"

B. For existing housing

MLEV	H347	M	Total	1969:01-1991:12
MLENHAV	H348	M	NHA total	"
MLENHAVS	H349	M	NHA singles	"
MLENHAVM	H350	M	NHA multiples	"
MLECONV	H351	M	Conventional total	"
MLECONVS	H352	M	Conventional singles	"
MLECONVM	H353	M	Conventional multiples	"

(11) Mortgage Rates (in per cent)

RMCB1YR	B14050	M	Chartered bank typical rate on 1 year mortgage	1980:01-1992:03
RMCB3YR	B14052	M	Chartered bank typical rate on 3 year mortgage	"
RMCB5YR	B14051	M	Chartered bank typical rate on 5 year mortgage	1973:01-1990:12
RMCON5YR	B14024	M	Conventional 5 year mortgage lending rate	1961:01-1990:12

(12) Other Variables

HH**		Q	Number of households
KHS**		Q	Stock of single dwellings in units
KHM**		Q	Stock of multiple dwellings in units
NRCBC	D10284	Q	Business new residential construction in millions of dollars
NRCBK	D10438	Q	Business new residential construction at 1986 prices in millions of dollars
NRCGC	D10284	Q	Government new residential construction in millions of dollars
NRCGK	D10423	Q	Government new residential construction at 1986 prices in millions of dollars

POP	D1	Q	Population (thousands)	1961:1 - 1990:4
PDI	D10111	Q	Personal disposable income (millions of dollars)	1961:1 - 1990:4
RGOC35	B14010	M	Yield on Government of Canada 3-5 year bonds (per cent per annum)	"
RTBQ	B14007	M	91-day Treasury bill yields (per cent per annum)	1961:01-1990:12

* Data from CANSIM are available only from 1981:01.
Additional data for earlier period were provided by CMHC.

**Data on these variables have constructed from the annual data provided by CMHC.

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